Instruments

THE MAGAZINE OF MEASUREMENT
INSPECTION · TESTING · CONTROL

cluding the
JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA

d the
JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

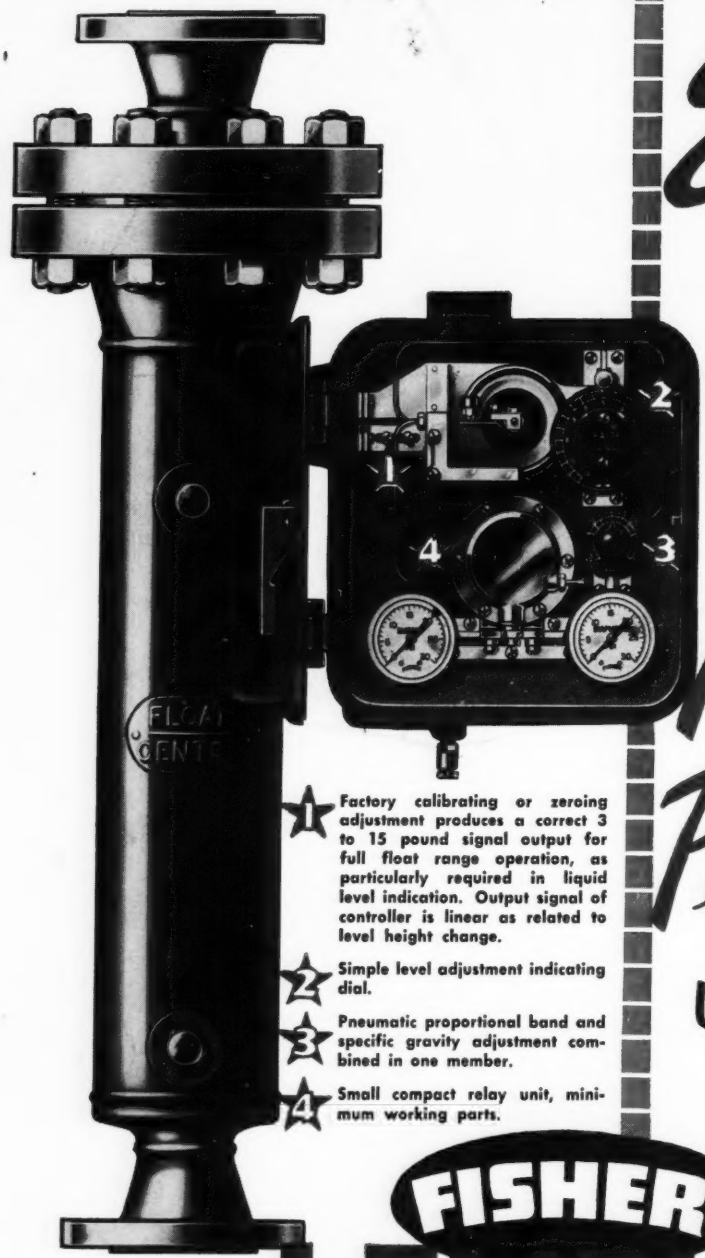
n this issue . . .

Seventh National Instrument Show
Selecting & Sizing Control Valves
Electronic Recorders
Instrument Electronics
Electron Diffraction Applications
Gas Regulation and Noise Control
Liquid Helium II
Radiation-instrument Department Store
114 New Instruments
110 New Bulletins

Control room of one of eight engine-test cells at Pratt & Whitney Aircraft, East Hartford, Conn. Crew of three put engines through five-hour proving runs. See story on page 830. *(Photo courtesy The Foxboro Company.)*

Vol. 25 No. 7
JULY • 1952

MEETS EVERY SERVICE REQUIREMENT



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1. Factory calibrating or zeroing adjustment produces a correct 3 to 15 pound signal output for full float range operation, as particularly required in liquid level indication. Output signal of controller is linear as related to level height change.
2. Simple level adjustment indicating dial.
3. Pneumatic proportional band and specific gravity adjustment combined in one member.
4. Small compact relay unit, minimum working parts.

Universally Accepted For

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- INTER FACE CONTROL

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Engineered for peak performance the Fisher Series 2500 Level-Trol is designed to give rugged, trouble free service. It is high in sensitivity and accuracy . . . it is versatile in handling all kinds of liquids, with minimum service attention. Fisher Bulletin F-3 gives full details . . . write for your copy today!

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WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

. . . provide DEPENDABLE ELECTRICAL CONTROL

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Ohmite Manufacturing Co., 4887 Flourney Street, Chicago 44, Illinois

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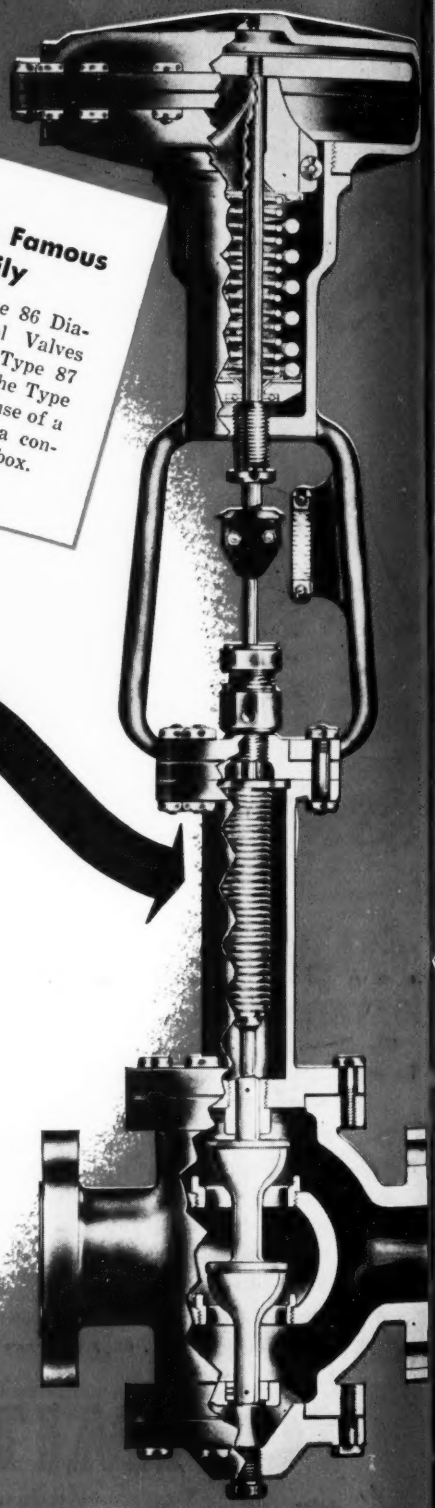
first **IN WIRE-WOUND RHEOSTATS AND RESISTORS**

TAKE NO CHANCES WITH SLIGHT LEAKAGE

APPLICATION: Where even slig leakage of a flowing medium mig become obnoxious, dangerous excessively expensive.



Specify

BS&B CLIMAX

Type 87 Diaphragm Control Valves

From The Famous Family

of Climax Type 86 Diaphragm Control Valves . . . the NEW Type 87 . . . identical to the Type 86 except for the use of a bellows seal plus a conventional stuffing box.

. . . with bellows sealed stem

Constantly striving to improve an already satisfactory item—that's part of the BS&B policy, part of our way of doing business. For example, take BS&B Climax Type 86 Diaphragm Control Valves of which the Type 87 is a family member. All Climax Type 87 valve bodies are designed to conform to I. S. A. tentative face-to-face standards. New designs continue to feature BS&B's interchangeability-of-parts advantage for greater operating and maintenance economy.

Type 87 is manufactured for all services and in all materials that are contemplated by Type 86 and in sizes from ½" to 6". Bellows can be supplied in bronze, stainless steel, Monel, Hastelloy "B", Nickel or other special alloys suitable. Maximum working pressure 400 lbs. cwp. The conventional teflon packed stuffing box is installed at the point the valve stem passes out of the bellows casing to forestall any appreciable loss of flowing medium in case of bellows failure.

Ask your BS&B MAN...33 Branches...13 Sales Offices...Ask for New Climax Catalog Section 105—recently revised—or write Black, Sivalls & Bryson, a leader for 60 years in oil and gas producing and refining equipment...out in front with controls and equipment for the processing industries.

CLIMAX BS&B CONTROLS

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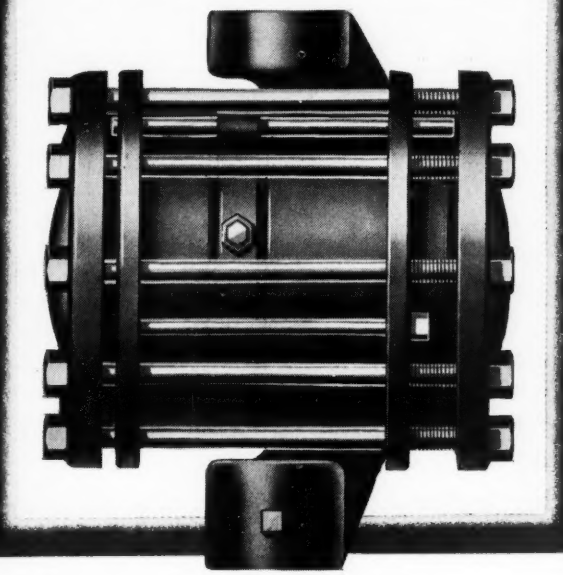
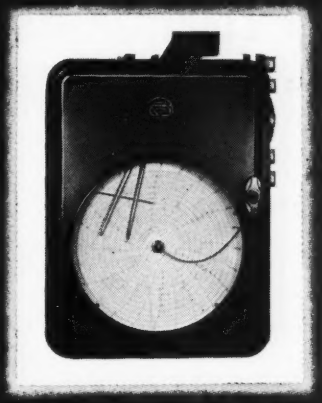
Climax Controls Division, Dept. 4-Y7

7500 East 12th St. Kansas City 3, Missouri

Now AMERICAN® offers...

THE *NEW* MERCURYLESS ORIFICE METERS





- **ONE PIECE STAINLESS STEEL BELLOWS—minimizes metal fatigue for long service life.**
- **DIRECT FULL SCALE RECORDING PEN MOVEMENT—no external gearing or linkage multiplication.**
- **STAINLESS STEEL INTERNAL PARTS—and Monel metal stuffing box shaft for corrosion resistance.**
- **AMERICAN TYPE "B" TEFLON SEAL STUFFING BOX—no lubrication, no shaft freezing, no leaks.**
- **STICK PROOF CHECK VALVES—protect bellows against over-range damage or distortion.**
- **SIMPLIFIED RANGE CHANGE—no disconnecting manifolds.**
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NO PRECISE LEVELLING OR SEAL POTS REQUIRED.

FOR PEDESTAL, PANEL OR OVERHEAD MOUNTING—TOP OR BOTTOM GAUGE LINE CONNECTIONS.

Dri-Flo Meters are the latest addition to the American line—developed under the Company's century-old tradition of "Sustained Accuracy at Lower Cost."

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INCORPORATED ESTABLISHED 1836

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Quality is assured with
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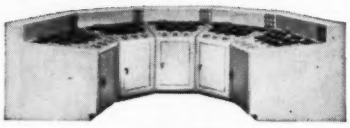
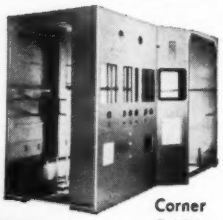
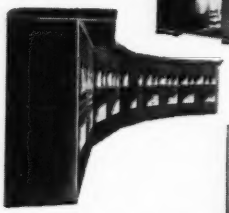
INSTRUMENT PANELS
and CONTROL BOARDS



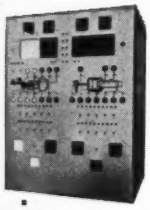
Benchboard Console



Five Section Cubicle Control Board and Lighting Canopy



Corner Cubicle Section



Refinery Cubicle with Mimic Flow Diagram in Color

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FALSTROM YOUR LOGICAL CHOICE!

Experienced designing and quality fabrication assure the efficiency of any indicating, recording, or control installation. Whether you are planning new construction, modernizing existing installations or adding to present equipment, FALSTROM offers long years of experience and the most modern facilities for fabricating to your specifications or recommending standard designs. In any case, by specifying FALSTROM you specify the highest possible quality metal working techniques known to the industry. Estimates on your needs will be supplied promptly—call or write FALSTROM to arrange a consultation.

WRITE FOR BULLETIN #125

Look for us at the 7th National Instrument Exhibit, Booth #720, Sept. 8th to 12th, Cleveland Municipal Auditorium, Cleveland, O.

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92 Falstrom Court, Passaic, New Jersey
DESIGNERS, ENGINEERS AND BUILDERS OF CUSTOM METAL PRODUCTS FOR INDUSTRY

Instruments

THE MAGAZINE OF MEASUREMENT INSPECTION · TESTING · CONTROL

Vol. 25 JULY 1952 No. 7

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Continued on page 830

LEWIS

SELECTOR SWITCHES
FOR
RESISTANCE THERMOMETERS
AND
THERMOCOUPLE THERMOMETERS

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Switch Part Numbers

Points	Size	Thermocouple Type	3 Wire Resistance-Thermometer Type
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2" SIZE

3" SIZE

SPECIAL SWITCHES

No. 37S6C2, Four "4 Point and OFF" thermocouple switches combined in one 3″ case.

No. 9S5, Single Pole, Four Point Instrument Switch in 1¼″ round case.

No. 44S4, Six Pole, Double-throw Instrument Switch in 2½″ round case, one hole mounting, ½-32 threaded bushing.

4" SIZE

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

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Manufacturers of *Complete* Temperature Measuring Systems for Aircraft
NAUGATUCK, CONNECTICUT

Stable as a *Wirewound* Resistor*

MODEL "R" VOLTMETER

SIE

DC VOLTS
DC MILLIVOLTS
AC VOLTS
AC MILLIVOLTS
OHMS
MEGOHMS
STANDARD CELL
DC AMPLIFIER

THE MODEL "R" VOLTMETER

The Model "R" is primarily intended for the precise measurement of DC potentials, providing DC voltage ranges from one volt full scale to 1,000 volts full scale; however, to allow the instrument its greatest possible utility, the following auxiliary functions have been included in its design:

Distended DC Voltage Ranges: Bucks out 99% of measured voltage and indicates 1% of measured voltage full scale.

DC Millivolt Ranges: One millivolt full scale to 1,000 millivolts full scale.

AC Volt and Millivolt Ranges: One Millivolt full scale to 1,000 volts full scale.

Self-Contained Standard Cell: For instant check of voltmeter calibration.

Ohms Ranges: Times one to times 10^6.

Distended Ohms Ranges: Reads bottom half of ohms scale full scale.

DC Amplifier: Will drive a one ma recorder, has gain of 200, and frequency range of zero to 100 kc.

*This statement refers to the fact that precision wire-wound resistors are used for all attenuators and range resistances, and that the DC Amplifier is a highly degenerative system employing wirewound resistors for the beta network. It has been found that changes in gain with warm-up are in the order of .1 of 1% and are primarily due to the temperature coefficient of the resistors in the beta network.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

2831 Post Oak Road • HOUSTON, TEXAS, U.S.A.

Instruments

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COVER STORY

Crew of three in the control room of one of eight engine-test cells at Pratt & Whitney Aircraft, East Hartford, Conn., puts aircraft engines through 5-hour proving runs. Instruments record temperatures and oil pressures at numerous points continuously during the run, as well as computing power output, and fuel and oil consumption. Oil pressures at seven key points are watched by Foxboro "Dynalog" concentric indicators shown in the panel. These "Dynalog" indicators furnish sensitive electronic response to engine oil-pressures at the engine, more than 60 feet from the instrument panel. After the initial "green" run, the engines are torn down completely, carefully inspected, and then re-assembled for a final test run.

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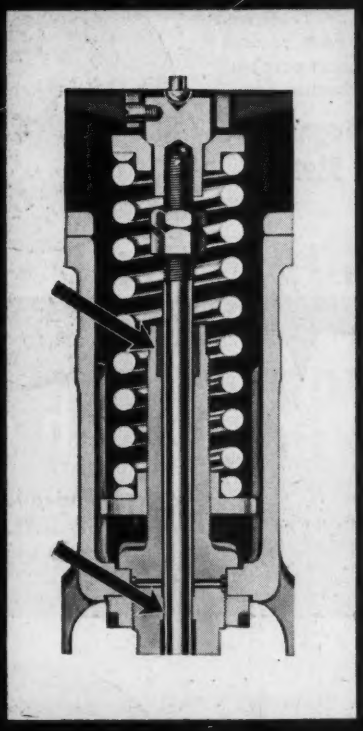
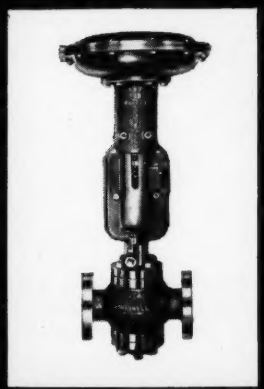


GUIDED STROKE...

for smoother stem movement



The two-point guiding of the upper stem in the Honeywell Series 700 Valve eliminates side thrust by supporting the stem at top and bottom in continuously lubricated bearings . . . assuring practically frictionless response to the slightest changes in signal air pressure. The Honeywell Series 700 wide band proportional valve comes in a full range of styles and sizes . . . has *all* the features you look for in a fine valve. Write today for your copy of Bulletin 700-2.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division,* 1908 Windrim Avenue, Philadelphia 44, Pa.

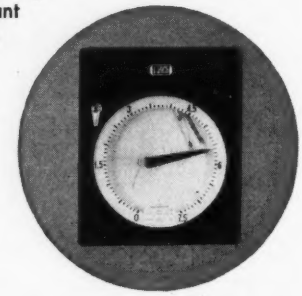
MINNEAPOLIS
Honeywell
VALVE PRODUCTS

First in Controls

Measures fundamental indicator of combustion efficiency—Oxygen. Applicable to power plants and process problems like catalytic crackers, open hearths, process heaters, inert gases, etc.

PRINCIPLE — Based on paramagnetic (attracted by magnetism) properties of Oxygen.

FEATURES — Highly sensitive to change in 0_2 content — responds rapidly. Electrically operated. Electronic type recorder. Temperature controlled. Pressure compensated. No liquid or gaseous fuel required. No chemicals. Highly accurate. Not affected by wide change of gas flow rate. Continuous sampling and recording. Glass and corrosive resistant sampling system. Remote mounted analyzer and recorder. Four records on same chart possible. Low maintenance.

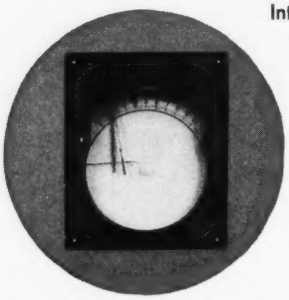


Hays Magnotherm O_2 Meter

Provides a *QUANTITATIVE* guide to efficiency — deals with quantities of air and steam; by contrast CO_2 and O_2 meters are *QUALITATIVE* guides since they determine directly quality of combustion gases.

PRINCIPLE — Record of steam flow is assumed to be Btu's produced; record of air flow is calibrated to flow of air required to generate that steam.

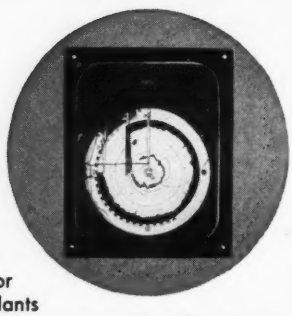
FEATURES — Electric operation of flow meter and air flow recorder. Diaphragm-type air flow measuring unit. Air flow measuring element does no work. Air flow recorder—motor operated. Adjustable cam air flow calibration. Mercury transmitter — pressures to 2500 psi. Interchangeable range tubes for steam flow. Remote mounted steam flow transmitter. No high pressure piping into panel. Easily installed and adjusted. Low maintenance.



Hays-Penn Boiler Efficiency Meter

Which combustion guide is best?

IT DEPENDS . . . on the fuel you're burning, the accuracy you require, the price you want to pay, etc. Your particular needs will determine your choice . . . but remember—only Hays can supply you *without bias* . . . because only Hays has a *complete* line of Combustion Guides.

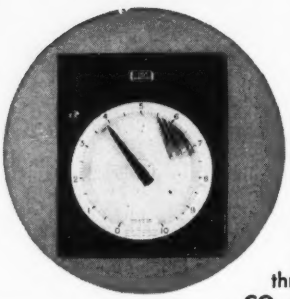


Hays Combustion Meter

Hundreds of these meters have been in operation for many years in all types of plants burning all kinds of fuels and saving thousands of fuel dollars.

PRINCIPLE — Operates on Orsat principle of volumetric measurement and chemical absorption. Difference in sample before and after absorption gives exact percentage of CO_2 absorbed by chemical.

FEATURES — Low price. Water operation. Pressure and temperature compensated. Volumetric determination. Chemical absorption. 2-minute operating cycle. Easily understood. Rugged construction. Low maintenance. Available in 6 remote mounted types and 3 integral types: (a) CO_2 only—recording with or without indicator (b) CO_2 and flue gas temp. recorder combined (c) CO_2, draft or flue gas temp. recorder combined. Remote or integral mounting.



Hays Condu-Therm CO_2 Meter

A *new* instrument using three *established* ideas: (1) CO_2 as guide to combustion efficiency (2) thermal conductivity principle (3) electronic type operation.

PRINCIPLE — Based on thermal conductivity of gases, i.e., that all gases conduct heat at different rates.

FEATURES — 5-second response to change in CO_2 content. ± .25% accuracy for ranges 0 to 20%. Electrically operated. Electronic type recorder. Temperature controlled. Humidity controlled. No chemicals required. No moving parts in analyzer. Continuous sampling. No drying agent required. Unmatched construction features. Not affected by wide change in gas flow rate. High sensitivity. Rapid response. Continuous recording. Remote mounted analyzer and recorder. Low maintenance.

THE HAYS CORPORATION

MICHIGAN CITY 8, INDIANA

Automatic Combustion Control • Boiler Panels • Hays-Penn Flowmeters
Veriflow Meters and Veritrol • Gas Analyzers • Draft Gages
Combustion Test Sets • CO_2 Recorders • Electronic Oxygen Recorders

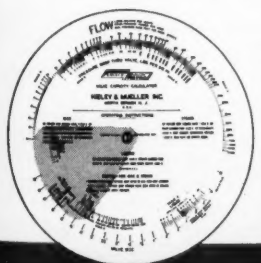
AMERICA'S LEADING INDUSTRIES PUT THE STAMP OF APPROVAL ON KIELEY & MUELLER CONTROL VALVES

Make It Your Business to Find Out Why!

All over the country leading companies in the process industries are solving tough problems with K & M control valves, designed especially for precise and positive control by instrumentation.

More and more, as the outstanding performance of these superbly engineered valves becomes known, important companies with pressure and flow applications are turning to K & M for the skill, knowledge and experience that assure reliable automatic control of pressures, temperatures, rates of flow and liquid levels.

There is a qualified K & M representative near you, eager to discuss your control problems and able to provide the most satisfactory solution.



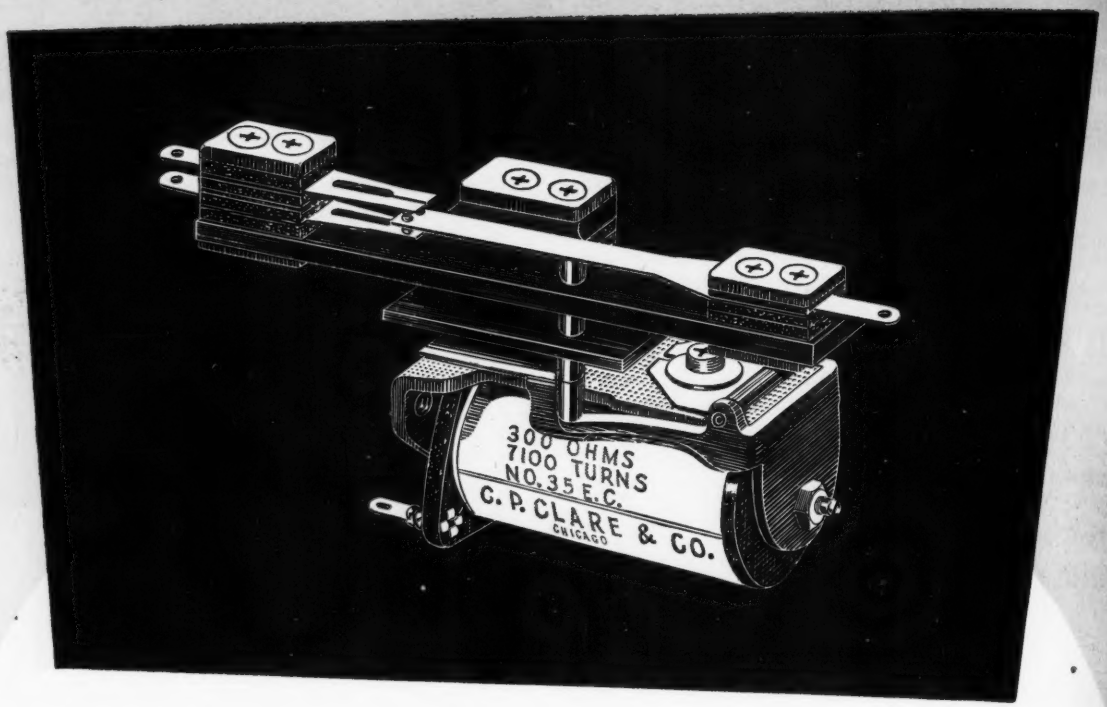
This extremely accurate circular slide-rule type K & M valve capacity calculator includes correction scales for steam quality, liquid and gas specific gravity and a flowing temperature scale for gases. Sent without charge in response to a request on your business stationery.

K&M

KIELEY & MUELLER, INC.

Valve Makers Since 1871

2023 - 43rd STREET NORTH BERGEN, N. J.



"WE WANT A RELAY THAT..."

That's the signal for ACTION at CLARE!

Almost simultaneously CLARE received requests not long ago from one of the world's largest manufacturers of radio and television equipment and from a nationwide broadcasting system. They presented similar but not identical problems.

Both involved relays for switching circuits carrying video frequencies present in the output of television cameras—frequencies ranging from almost zero to several million cycles. The capacitance between one contact spring and another, as well as between the contact springs and the frame of the relay must be extremely low. Available relays were too large and cumbersome—a typical relay extant at that time occupied 17 cubic inches—their operate, release and transfer times were too slow, and they were full of contact bounce.

These customers were familiar with the versatility of the CLARE Type J Relay. They asked us to try to adapt it for switching high-frequency currents. The Type J Video Relay was the result of intelligent cooperation between CLARE and the customers' engineers. It has negligible contact bounce and is otherwise superior to previous designs; and it occupies only about 7 cubic inches. It proved to be ideally suited to the needs of both customers, and it is now in high demand.

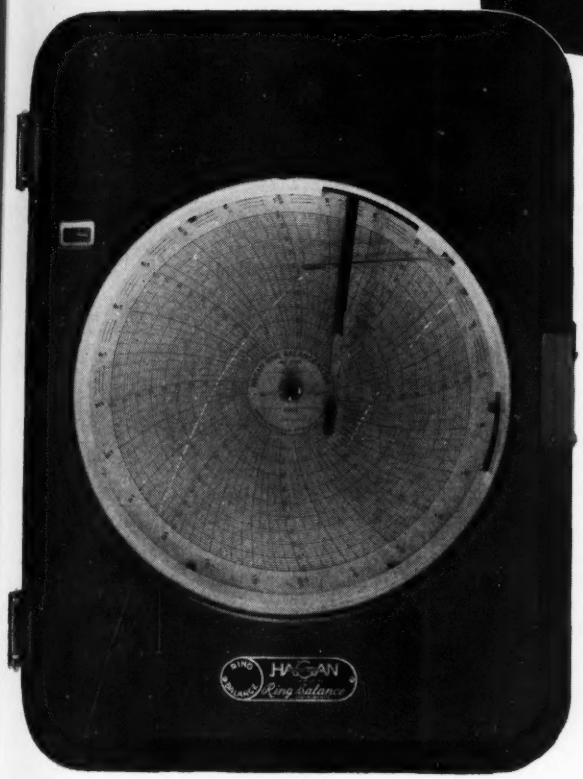
Bringing relay problems to CLARE by leading manufacturers has resulted in many outstanding relay developments. You, too, can save time, money and often needless experiment by contacting the nearest CLARE sales engineer. Call him today or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

First in the Industrial Field

No stuffing box troubles in

HAGAN RING BALANCE METERS



because there are no stuffing boxes!

Forget about stuffing box troubles and pressure tight bearings when you install Hagan Ring Balance Meters. The simple, flexible S-tube connections to the ring assure dependable accuracy and trouble-free operation.

Features of the Hagan Ring Balance Meter include:

- **Calibration can be checked under operating conditions by check-weight method**
- **Excellent response at extremely low flow rates**
- **Mercury level not critical**
- **Full-scale chart differential is adjustable over a 7-to-1 range**

HAGAN CORPORATION

HAGAN BUILDING
PITTSBURGH 30, PENNSYLVANIA

Our engineers will be glad to show you how Hagan Ring Balance Meters can help solve your metering problems. Use the coupon, or write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

Hagan Corporation
Hagan Building • Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in .....

.....

NAME.....

POSITION.....

COMPANY.....

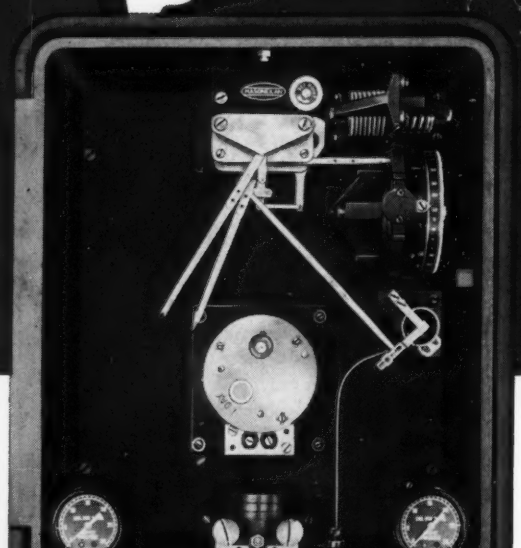
STREET AND NUMBER.....

CITY.....ZONE.....STATE.....

I-7

So You Want to Buy a

Of course you'll compare the various models offered. You will note that:—



All have the same basic components . . .
primary element, proportioning mechanism, pilot.

All operate on same basic principle . . .
measure changes in controlled variable, apply corrective measures by regulating an output pressure.

BUT HERE THE DIFFERENCES BEGIN

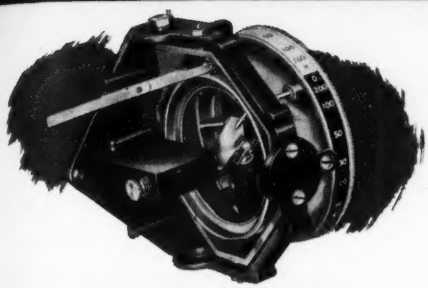
differences that are important to the instrument man and operator: differences in design and arrangement which result in great variations in simplicity, versatility, reliability and ease of adjustment and servicing.

For example, note how refinements in design make the Masoneilan 60000 Series Controller outstandingly different from most other types —

A HIGH Cq PRODUCT

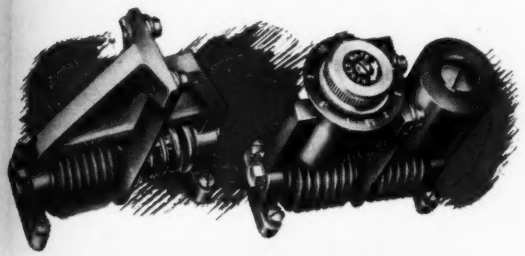
SEE THEM AT THE INSTRUMENT SHOW . . . BOOTHS 435-43

a Pneumatic Controller!



THE GIMBAL UNIT...

the heart of the mechanism which regulates the flow of power from the controller — selects *four* combinations of primary and feedback motion to provide proportional, differential-gap and on-off control with direct or reverse action — makes this controller more versatile than any other. The proportional band wheel, by one simple adjustment, selects the *type* of control, the *action* and the proportional band or differential-gap *setting.*

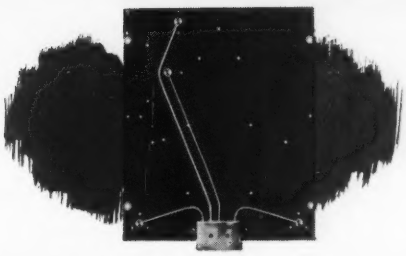


INDIVIDUAL, INTERCHANGEABLE SUBASSEMBLIES...

without linkage complexities, provide for (a) addition of standard subassemblies *easily*, to obtain pneumatic set, time schedule, differential control; (b) *easy* interchange of standard proportional and proportional-rest units; (c) ease of servicing because each sub-assembly is *individually* accessible.

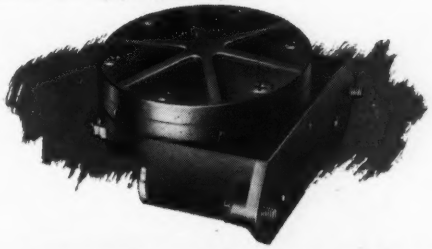
EASE OF ADJUSTMENT...

provided by accessibility without removing chart; by large knobs and large diameter proportional band wheel; by easily read graduated scales.



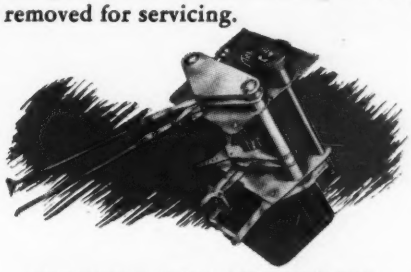
MANIFOLDING OF ALL AIR PASSAGES

with plug-in connections (a) aids accessibility, (b) eliminates pressure fittings, (c) permits interchange of components or addition of manual control subpanel *without piping changes.*



BALANCED, AMPLIFYING PILOT...

insures maximum capacity and stability in flow of output pressure. Includes latest refinements such as plunger-cleaned sapphire restriction, filters in outlet and inlet ports, frictionless floating valve action. Easily removed for servicing.



MULTIPLE PEN MOVEMENT...

provides common axis of rotation for pens and index, ball pivots, index setting by manual or automatic (e.g., Pneumatic Set, Time Schedule, etc.) adjustment.

With accurate, stable performance plus unmatched simplicity, versatility and reliability — the Masoneilan 60000 Series Controller is truly the Instrument Man's Instrument for pressure, temperature, liquid level or flow control.

MASON-NEILAN REGULATOR CO.

1210 ADAMS STREET, MASONEILAN **BOSTON 24, MASS., U. S. A.**

Sales Offices or Distributors in the Following Cities:
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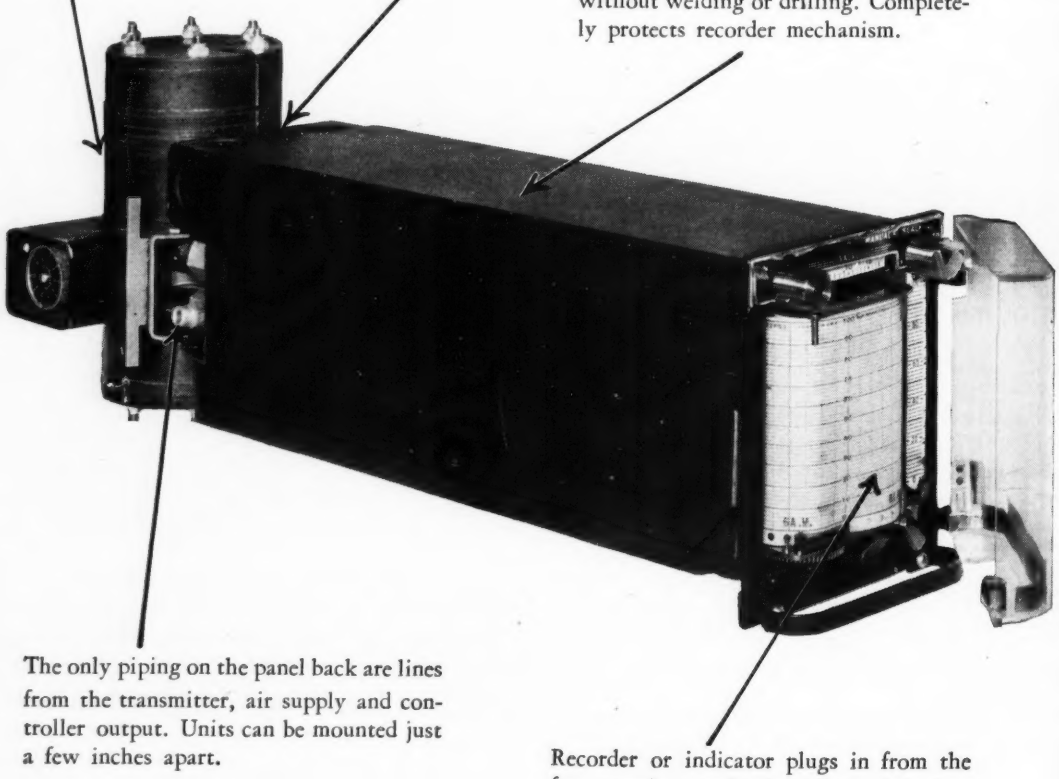
Both Controllers and R



One common, self-sealing manifold gives plug-in connections to both receivers and controllers!

The plug-in controllers can be removed and replaced with another unit in just 10 seconds.

Rugged steel sleeve clamps on panel, without welding or drilling. Completely protects recorder mechanism.

The only piping on the panel back are lines from the transmitter, air supply and controller output. Units can be mounted just a few inches apart.

Recorder or indicator plugs in from the front—units can be interchanged in just 10 seconds.

nd Receivers PLUG IN like a radio tube

in Taylor's new Transet® Control System

HERE'S a new and greater TRANSET Pneumatic Control System! It incorporates all the superior control features and control accuracy that has made TRANSET 3-part control such an overwhelming success since its introduction. Now we have *added* all these *new* benefits:

1. All units can be mounted on the panel without welding, without drilling holes.

2. A single mounting is all you need for both controller and recorder or indicator.

3. You can change from simplest to most complex control as easily as changing tubes in a radio, simply pulling out one unit, plugging in a new one.

4. You can change from indicator to recorder, or vice versa, the same way—in only 10 seconds.

5. The only piping connections required are air supply, controller output and to the variable transmitter. All other connections are made automatically, in the self-sealing manifold.

6. You save panel space, because units can be mounted only a few inches apart.

7. You save money, both in labor and materials on installation—thanks to the simplified piping and mounting.

8. All adjustments on the recorder or indicator can be reached conveniently, from the front, without disturbing any connections.

9. Mountings are so rugged, attach to panel so sturdily, that they would support the weight of an average man.

All these features, and many more, have been added to the famous Taylor TRANSET Control System. Before you make any decision involving pneumatic transmission control, be sure to get information on the new and greater plug-in type TRANSET Control. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

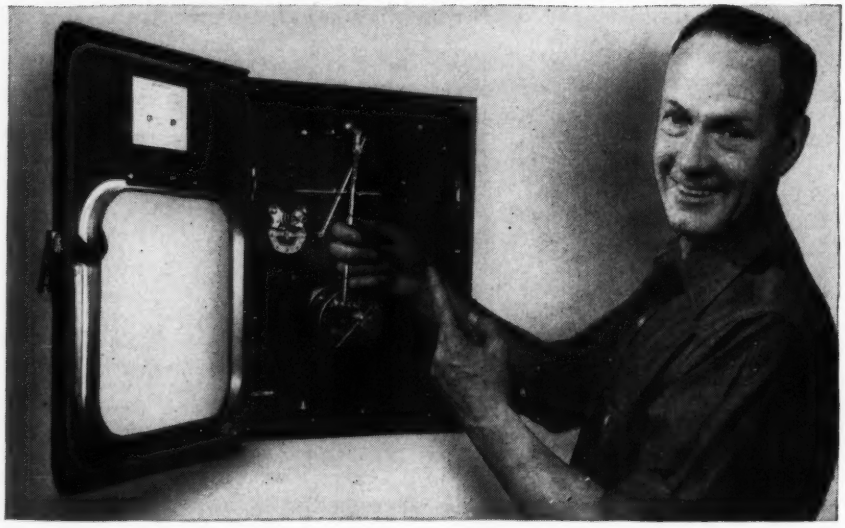
Taylor Instruments

MEAN

ACCURACY FIRST

IN HOME AND INDUSTRY

No replacement fits a Bristol Instrument so perfectly as a Bristol replacement*!



* Who is better equipped than the actual maker of the instrument to make component parts that fit it precisely? Don't risk the lack of precision—which even a slight inaccuracy or misalignment in a component may cause—when you can avoid it so easily by simply specifying Bristol replacements. Quick delivery.

THE BRISTOL COMPANY, WATERBURY 20, CONNECTICUT

BRISTOL *The dependable Guidepost of Industry*

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Kelburn Engineering Company
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Harry M. Wood
124 Light Street

MASSACHUSETTS, Boston 15
Gibson Engineering Company
1018 Commonwealth Avenue

MICHIGAN, Detroit 26
Ralph D. Ernest
408 Penobscot Bldg.

MINNESOTA, St. Paul
R. A. Lundbeck
1900 University Avenue

MISSOURI, St. Louis 10
Louis D. Moore
604 Chouteau Bldg.
4030 Chouteau Avenue

NEW YORK, Buffalo 2
Douglas J. Munhall
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OHIO, Cleveland 3
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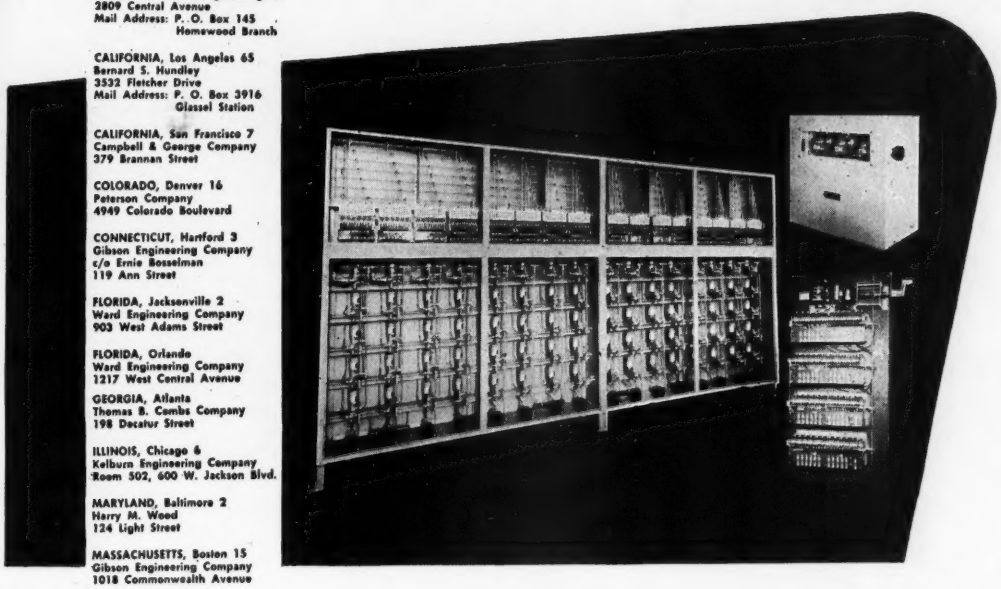

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Industrial Timers
EAGLE SIGNAL CORPORATION MOLINE, ILL.

control panels

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PENNSYLVANIA, Upper Darby
W. F. Keegan Company
771 Shelbourne Road

TEXAS, Dallas 1
Lynn Elliott Company
Room 521
Second Unit, Santa Fe Bldg.

TEXAS, Houston 2
Lynn Elliott Company
371 M & M Building

UTAH, Salt Lake City 7
Sherman C. Nabaum Company
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WASHINGTON, Seattle 1
Instrument Sales Company, Inc.
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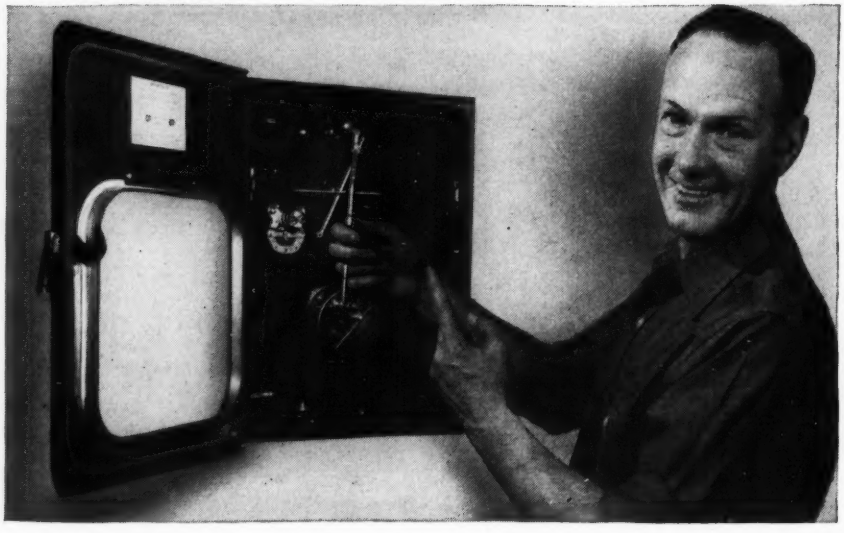
large or small

Let Eagle Signal turn your control problems to profits. Automatic precision timing will increase quality and production of your industrial process. Eagle will design and build any size panel, complete, ready to plug in and produce for you. See your Eagle representative or write today. No obligation.

No replacement fits a Bristol Instrument so perfectly as a Bristol replacement*!



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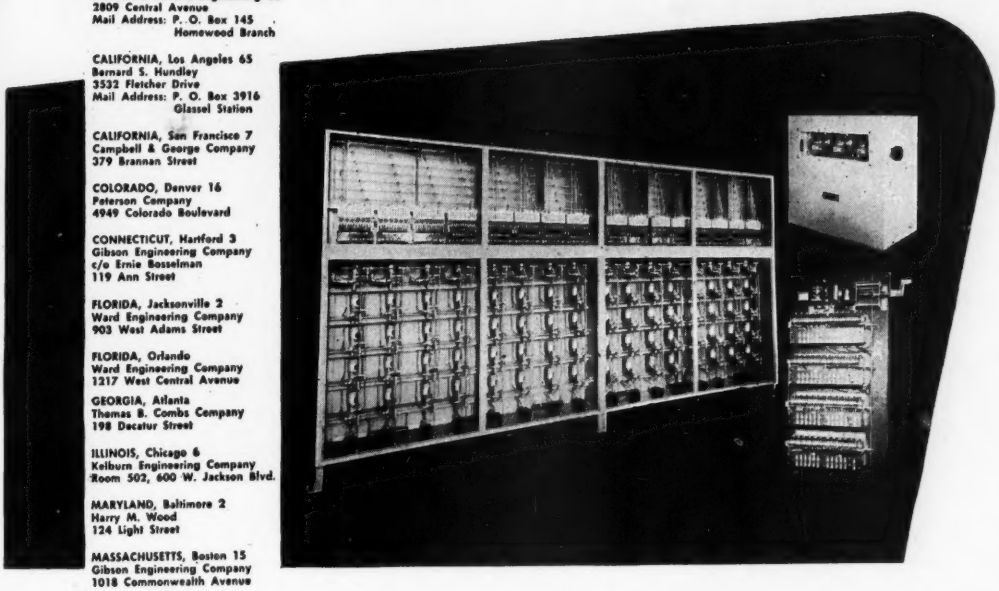

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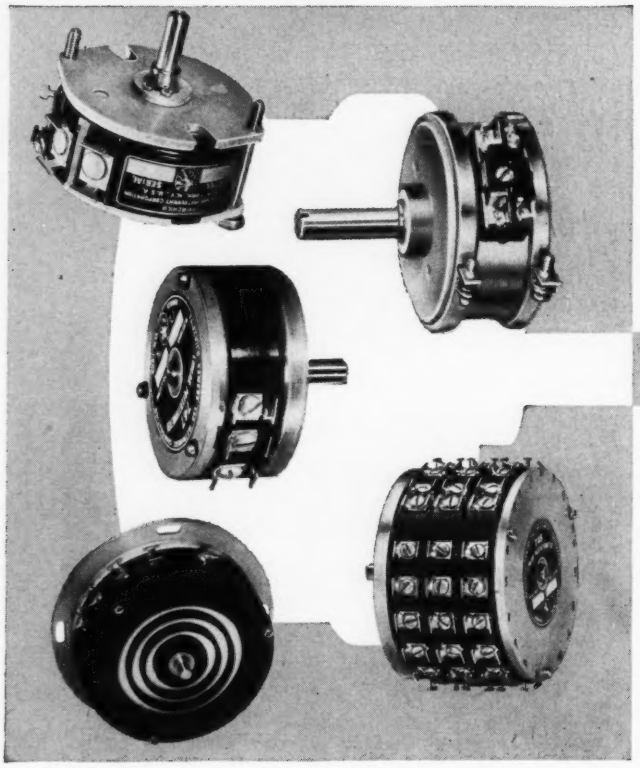
large or small

Let Eagle Signal turn your control problems to profits. Automatic precision timing will increase quality and production of your industrial process. Eagle will design and build any size panel, complete, ready to plug in and produce for you. See your Eagle representative or write today. No obligation.

Where control accuracy is important... use Fairchild Precision Potentiometers



In many control systems, accuracy is the all-important factor. But the accuracy of an entire system depends on the proper functioning of each component.

Fairchild precision potentiometers are designed and built to meet extreme accuracy requirements. That's why they are being selected more and more for control systems where accuracy, limited weight and space, and simplicity are paramount.

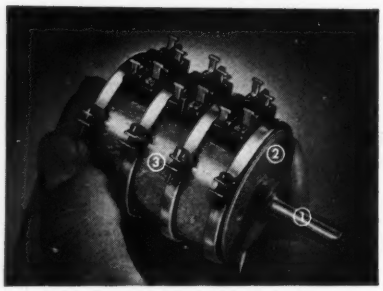
These potentiometers perform mathematical computations in electrical computing systems for machine-tool controls, aircraft instruments, aerial-camera controls, radar, guided missiles, gunsights, and analog computers of all types. They are available in non-linear and linear types and in ganged combinations of either or both, with windings to meet your requirements. If you have computer or control problems, ask for our recommendations about using Fairchild Precision Potentiometers to solve them.

HOW PRECISION IS DESIGNED AND BUILT INTO FAIRCHILD POTENTIOMETERS

1. Shaft is centerless-ground from stainless steel to a tolerance of +0.0000, −0.0002 in. which, together with precision-bored bearings, results in radial shaft play of less than 0.0009 in.

2. Mounting plate has all critical surfaces accurately machined at one setting to insure shaft-to-mounting squareness of 0.001 in./in. and concentricity of shaft to pilot bushing within 0.001 in. FIR.

3. Housing is precision-machined from aluminum bar stock. Close tolerance of this construction permits ganging up to 20 units on a single shaft with no eccentricity of the center cups, even though only two bearings are used for the entire gang.



4. Windings are custom-made by an exclusive technique. Guaranteed accuracy of windings in standard types is: linear, 0.5%; non-linear, 1.0%. Higher accuracies (to 0.05%) are available in other types. Guaranteed service life is 1,000,000 cycles.

DO YOU HAVE CONTROL PROBLEMS?

Fairchild Sample Laboratory engineers are available to help you with potentiometer problems. To get the benefit of their knowledge and experience write today, giving complete details, to *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, New York, Department* **140 26B1**

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PRECISION POTENTIOMETERS

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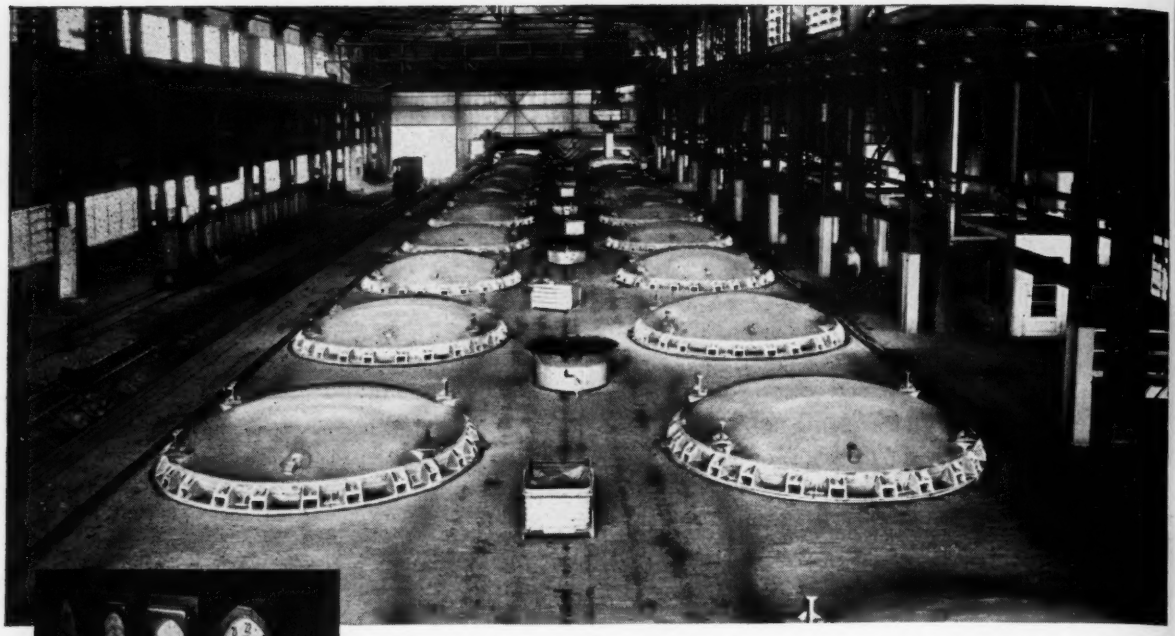

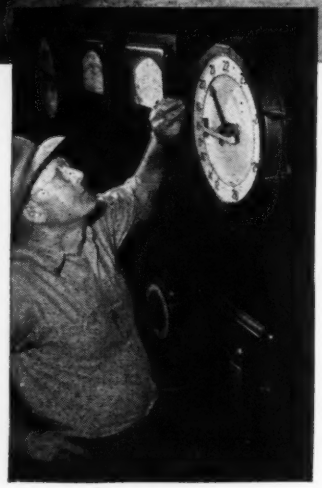

◂ Partial view of one of the control panels for C.F. & I. soaking pits. Heater is opening Micromax Controller case to change temperature control point.

▴ Part of C.F. & I.'s battery of 24 Salem soaking pit furnaces in Pueblo, Colo. plant. Control panels are in cubicles in right hand bay.

How C. F. & I. controls pit furnaces to give ingots

correct TEMPERATURE *and* SURFACE

The idea of employing instruments wherever they can be effective is doing a major job for Colorado Fuel & Iron Co. Engineers of C.F. & I. and of Salem Engineering Co. applied it with outstanding success in the soaking pits shown above. The net result is a plentiful supply of well-heated, properly-surfaced ingots from the big battery of 24 Salem round pit furnaces.

Regulation of the furnaces includes automatic control of temperature, combustion (fuel-air ratio) and draft (furnace pressure) in that order. The Micromax Temperature Recording Controllers preserve correct temperatures despite the effects of charging and pulling ingots, and changes in ambient conditions. With this basic fact of temperature under firm control, the other instruments can hold the equally important combustion factors at their correct respective settings. Furnace atmosphere can be made either neutral, oxidizing or reducing at any operating temperature. Draft can be made to hold the products of combustion to their proper path through the furnace for any operating load of ingots.

The L&N line today includes instruments, controllers and accessories in far greater variety than ever before. From among these standard equipments we can help you assemble control panels that are tailored exactly to the needs of any pit furnace . . . or any other industrial furnace. Just contact our nearest office or write us at 4955 Stenton Ave., Phila. 44, Penna.

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instruments · automatic controls · furnaces

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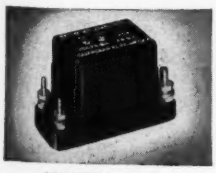
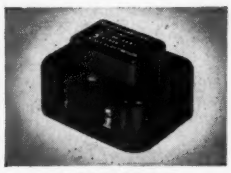
Series 595 D. C. RELAY

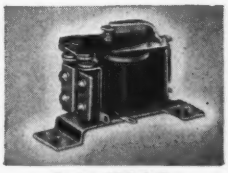
LUG HEADER CONTAINER



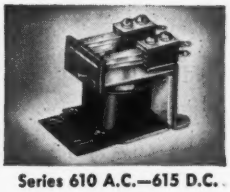
AN-3320-1 D.C.



AN-3324-1 D.C.



Series 220 A.C.



Series 610 A.C.—615 D.C.

Series 695 D.C.

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*Solid Colors or Spiral Marking

Everything in wiring

More and more—engineers, designers, production men and purchasing officials have come to regard Plasticord and Plasticote Wires and Cables by Chester as the standard of comparison. This is because every inch of these dependable insulated conductors is made to conform to exacting quality controls that assure long service life, and performance as specified by the factory. That's the reason electrical men, everywhere, look for the Chester trademark when they're looking for the best!

"Chesty" says—

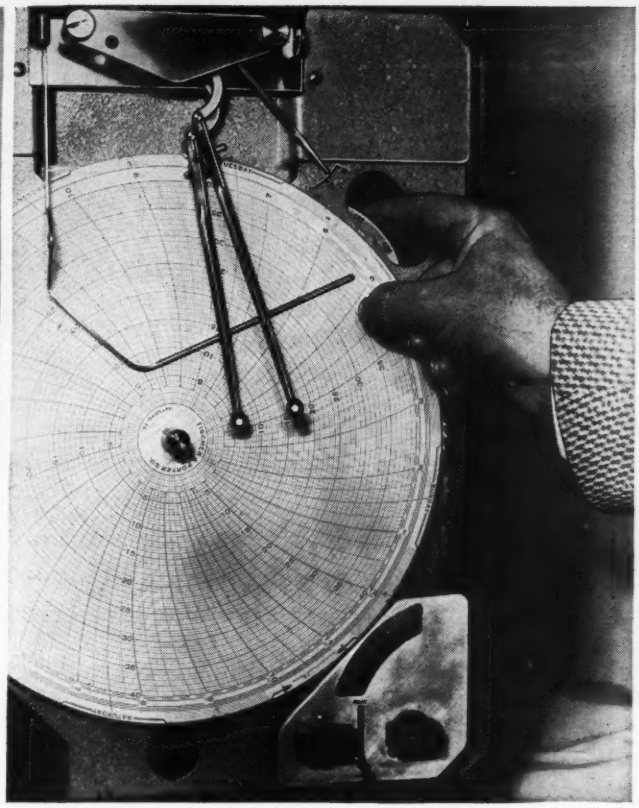
Our new catalog is a complete guide to plastic insulated wire and cable for every purpose. Write for a copy of this important data compilation for your files today.

CHESTER CABLE CORP.

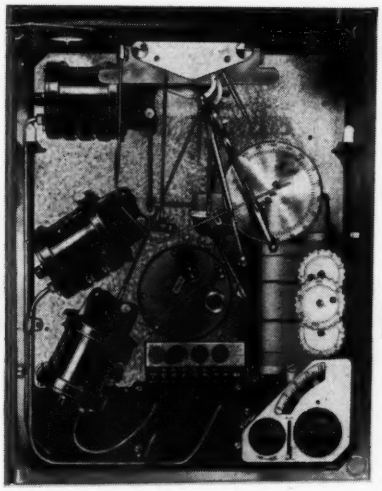
CHESTER, NEW YORK

MANUFACTURERS OF QUALITY WIRES AND CABLES FOR EVERY REQUIREMENT

NEW FISCHER & PORTER *automatic* FLOW RATIO CONTROLLER



Compact size with extreme precision of ratio control are important advances in this *new* Fischer & Porter Ratio Controller. Designed specifically for flow ratio control, it makes a perfect combination teamed with the new P-4 Pneumatrol and highly accurate Flowrator meters or variable area cell kinetic manometers, to assure accurate and dependable ratio control of fluids, gases or slurries. Receives pneumatic, electrical, or electronic primary signals. Review the features below, then mail the handy coupon for complete engineering and application data.



Interior view of standard Ratio Controller with pneumatic set ratio adjustment.

The compact stack mounting of the new Ratio Controller atop the P-4 Pneumatrol provides the simplest possible unit. The large (10½" scale) ratio setting dial permits precise ratio settings which are visible through the door. F&P wide range, linear scale primaries give extreme range of ratio (6:1 to 1:1 to 1:6; a total of 36:1).

CHECK THESE FEATURES:

- Extreme flexibility
- Wide range of ratio
- Based on linear scale primaries
- Control deviation indicator
- Primary element fully corrosion resistant
- Highly visible ratio setting dial
- Extremely compact stack mounting

1717

TRADE MARK FLOWRATOR

FISCHER & PORTER COMPANY

1370 COUNTY LINE ROAD, HATBORO, PENNA.

Please send me by return mail complete information on your new Ratio Controller.

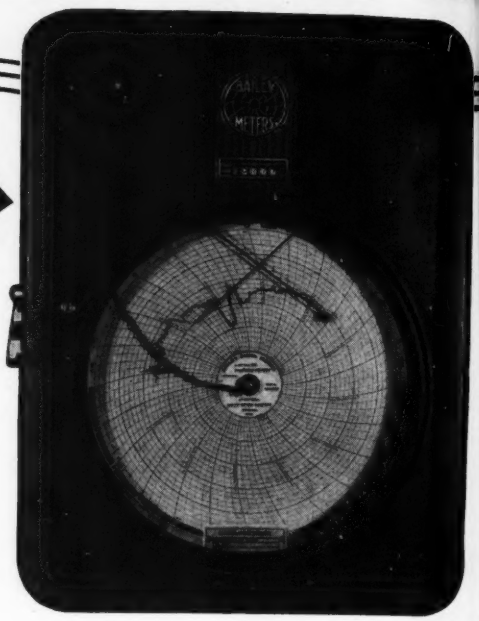
NAME_____ POSITION_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

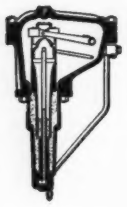
To Answer Your Fl



This standard Bailey Recorder actuated by mechanical, electrical, or pneumatic transmission solves even your toughest problems in flow measurement and control.

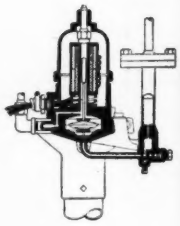
YOUR Choice of 7 Measuring Components:

...To measure steam, liquids, or high pressure gases in pipes use:



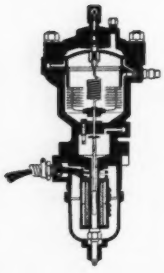
1 Ledoux Bell—

This shaped bell floating in mercury insures high accuracy and dependability throughout entire meter range. Records on uniformly graduated chart. For static pressures up to 2500 psig.



2 Mercury Float—

Actuates electric transmitter which has interchangeable range tubes. Electronic receiver records on uniformly graduated chart. For static pressures up to 2500 psig.



3 Bellows—

Actuates electric transmitter which requires no mercury, is readily portable and is easily adjustable to a wide variety of ranges. Electronic receiver records on uniformly graduated chart. For static pressures up to 3500 psig.

Bailey Meter Company

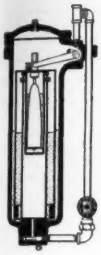
ur Flow Problems

...To measure liquids in pipes use:

4 Area Meter—

Variable area constant differential orifice actuates electric transmitter. For 1, 2 or 4″ lines in capacities from 1200 to 96,000 lb per hour and static pressures up to 600 psig.

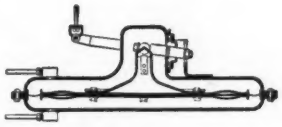
...To measure low pressure gases in pipes and ducts use:



5 Inverted Bell—

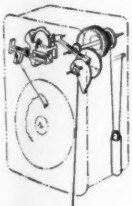
Sizes up to 12″ diameter furnish ample power with differentials as low as 2″ H_2O. Shaped displacer floating in mercury provides for uniformly graduated chart. Static pressure limits vary from 50 to 800 psig, depending upon bell size.

6 Diaphragm—



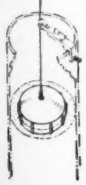
44 square inches in area opposed by shaped displacer floating in mercury actuates uniformly graduated chart recorder. Suitable for differentials from .5″ to 7″ H_2O and static pressures up to 70″ H_2O.

...To measure liquids in open channels use:



7 Open Float—

Actuates uniformly graduated chart recorder through pulley-operated cam and gear train. May be calibrated to any maximum head between 5″ and 360″ of liquid flowing in channel.



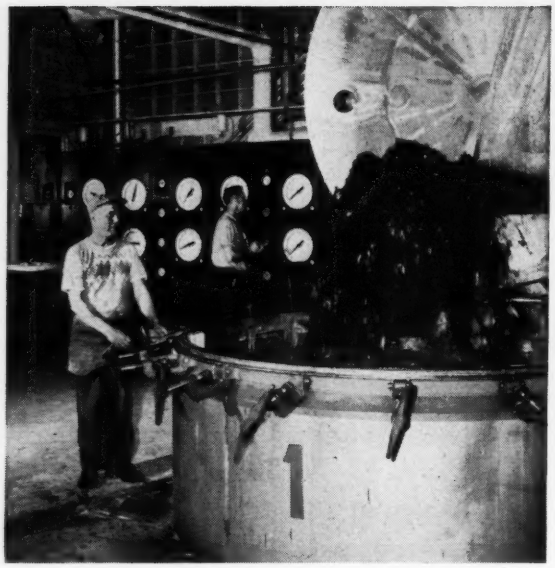
•

Ask your local Bailey Engineer to assist you in applying Bailey Meters to your measurement and control problems.

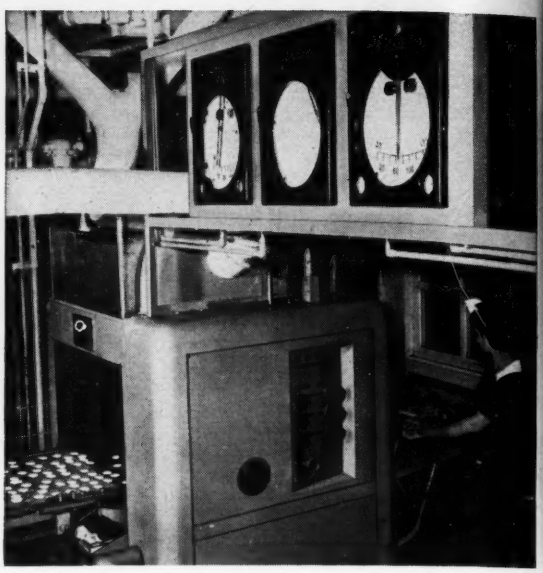
C-8

1041 Ivanhoe Road
CLEVELAND 10, OHIO

Meters and Controls
For
Power and Process



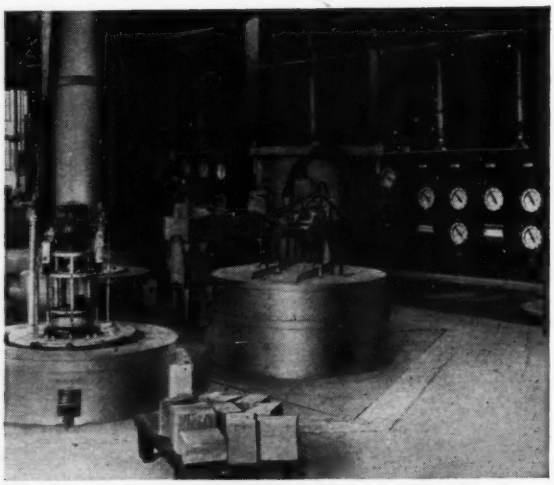
EXACT COLOR MATCHING *is important to quality carpet manufacturing . . . and depends, in part, upon the rigid maintenance of proper time and temperature schedules in the raw stock dye kettles. These* **ElectroniK** *controllers keep the schedules uniform and reproducible.*



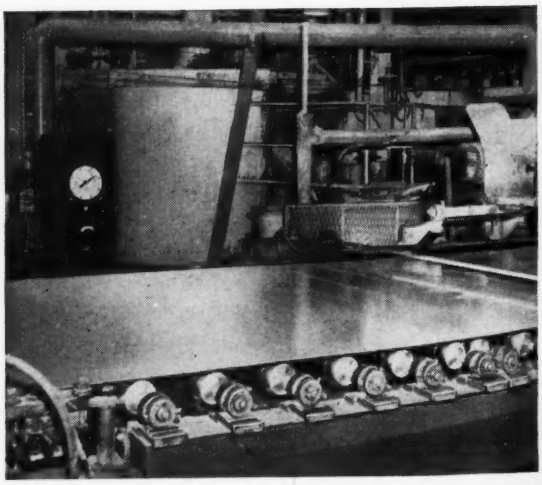
AUTOMATIC ENROBER CONTROL *system keeps the temperature of chocolate at precisely the proper point . . . for the mass production of quality candy. This same plant uses an automatic long cycle tempering to condition the chocolate before it enters the enrobers.*

From lab . . . to pilot plant . . . to

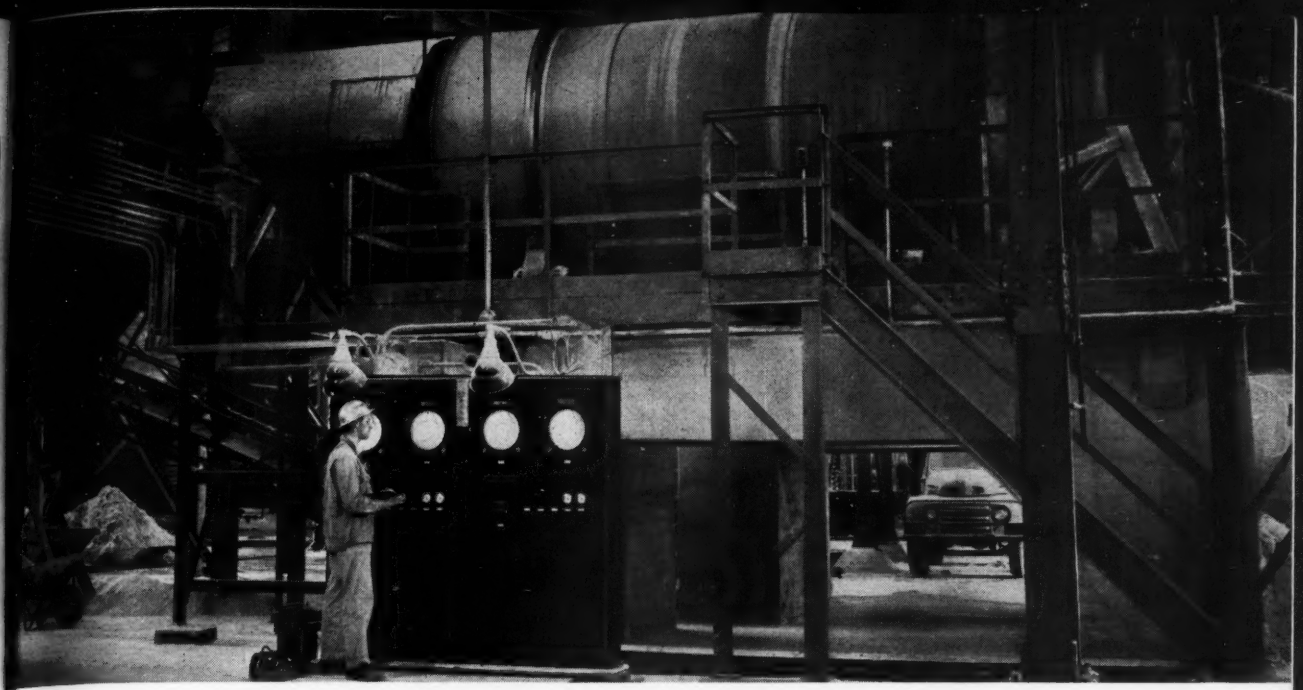
Instruments i



HIGH QUALITY *heat treating is a must for the dies used in precision forging of jet-engine turbine blades. These* **ElectroniK** *instruments provide the sensitive, accurate control of treating temperatures necessary for the meeting of exacting specifications.*



HOLDING PRODUCT QUALITY *at a high level is one of the many important functions of Brown instruments. The pH controller shown with this Fourdrinier machine is part of a complete control system which helps insure continuous production of top quality sheet and board.*



PRECISION DRYING *maintains uniformly low moisture content of chemicals from rotary drier, controlled by a coordinated team of Brown instruments which regulate gas temperatures.*

. . . to process operation

. . . to increase quality

QUALITY starts with research . . . expands its base in pilot plant investigations . . . emerges as a vital ingredient of full-scale production. At every step in the quality cycle, Brown instruments contribute essential assistance. They help the scientist to determine the ideal values of temperature, flow, pressure and other variables which will produce the desired results on a test-tube scale. And they enable the production man to apply this knowledge to full-size plant operations . . . by providing him with the same accuracy of measurement and control that served in the laboratory.

One of the farthest-reaching results of widespread instrument application is the realization that quality need not be compromised under the pressure of rising production. The same modern methods of measurement and control which help to boost efficiency and reduce operating costs also stand guard over product quality. This "triple-threat" service of Brown instruments makes them an invaluable asset in countless production processes.

Our local engineering representative will welcome the opportunity to discuss ways that modern instrumentation can improve quality in your plant. Call him today . . . he is as near as your phone.

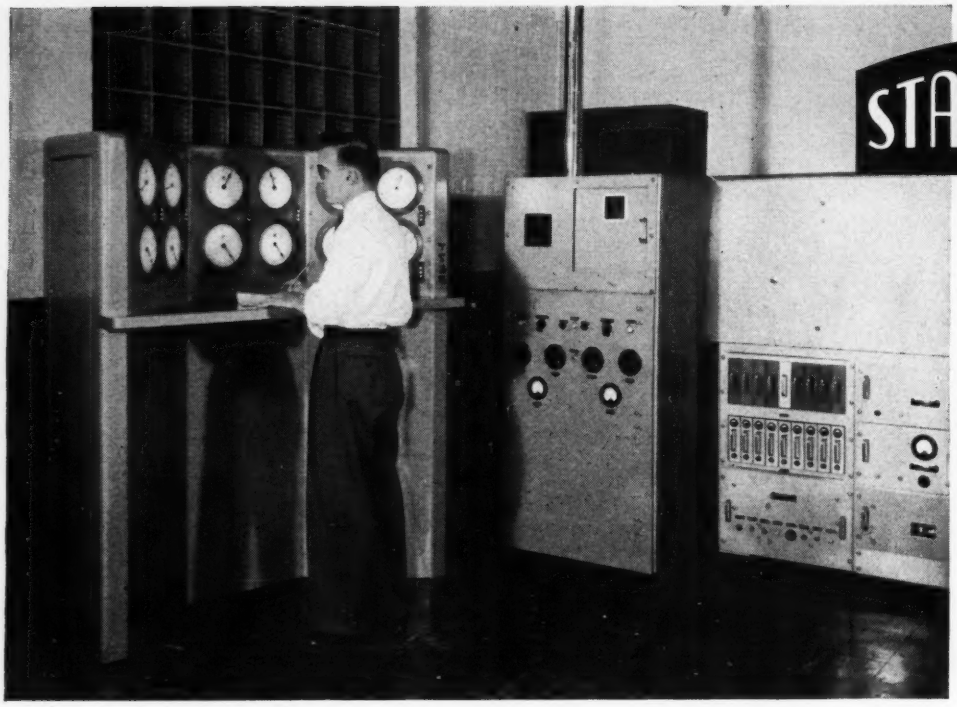
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa. Service facilities available in more than 55 cities in the United States.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

● *Important Reference Data*

Write for copy of new brochure, "Tomorrow Is Today"... and request Data Sheets on specific processing operations of interest to you.

Time and Time Again...



STANDARD

SINCE 1884

The Direct Reader shown was made by Baird Associates and includes Precision Timers by Standard.

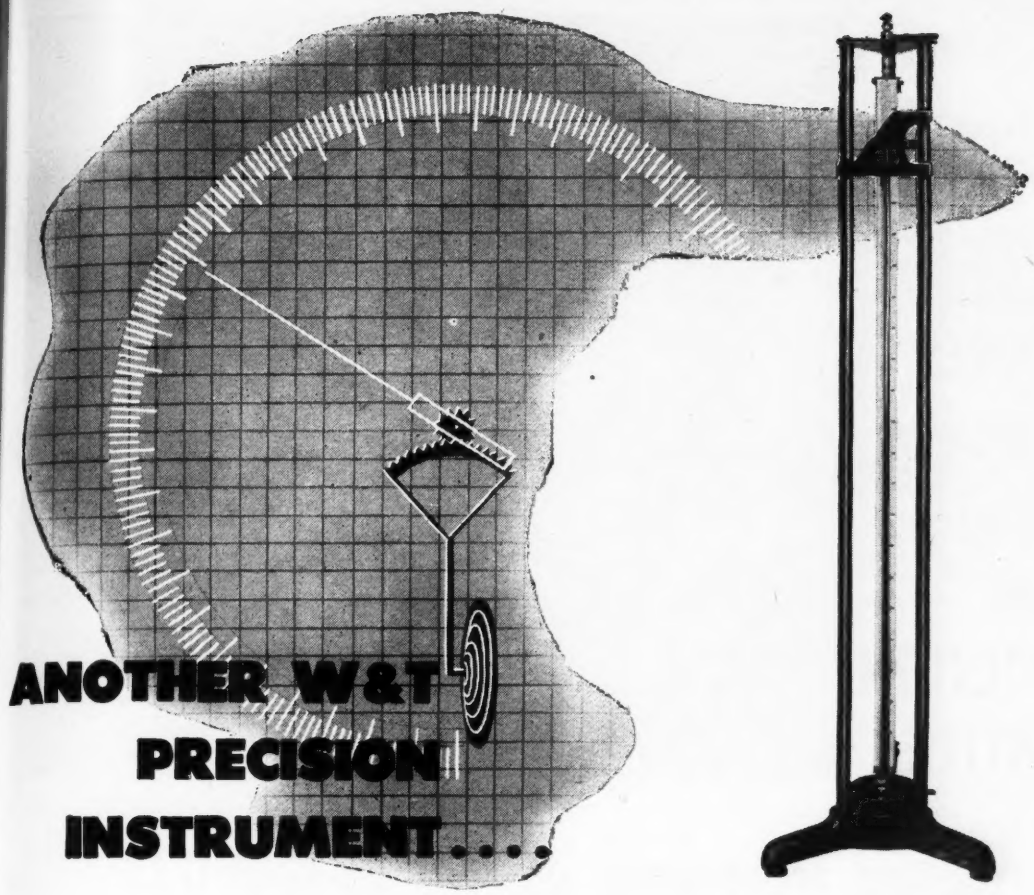
STANDARD ELECTRIC TIME Helps Attain High Degree of Quality Control at AMERICAN BRASS

Splitting the split second is often essential . . . Hours, days are cut to a mere 300 seconds at The American Brass Company, Waterbury, Conn. . . . where this Direct Reading Spectrometer completely analyzes an electric furnace charge of molten metal before it is even poured.

THE STANDARD ELECTRIC TIME COMPANY

93 LOGAN STREET • SPRINGFIELD 2, MASSACHUSETTS

PRECISION TIMERS • CHRONO-TACHOMETERS • LABORATORY PANELS • PIPELINE NETWORK ANALYZERS



ANOTHER W&T PRECISION INSTRUMENT....

The W & T Precision Mercurial Manometer

The W&T Precision Mercurial Manometer couples maximum precision with ease in handling. These two features have made it a leading instrument in modern research and manufacture for such uses as measuring sample pressures in infrared spectroscopy and calibrating aircraft altimeters. Because of its flexibility and accuracy, the Manometer can be used for almost any type of pressure measuring problem in the range of two atmospheres.

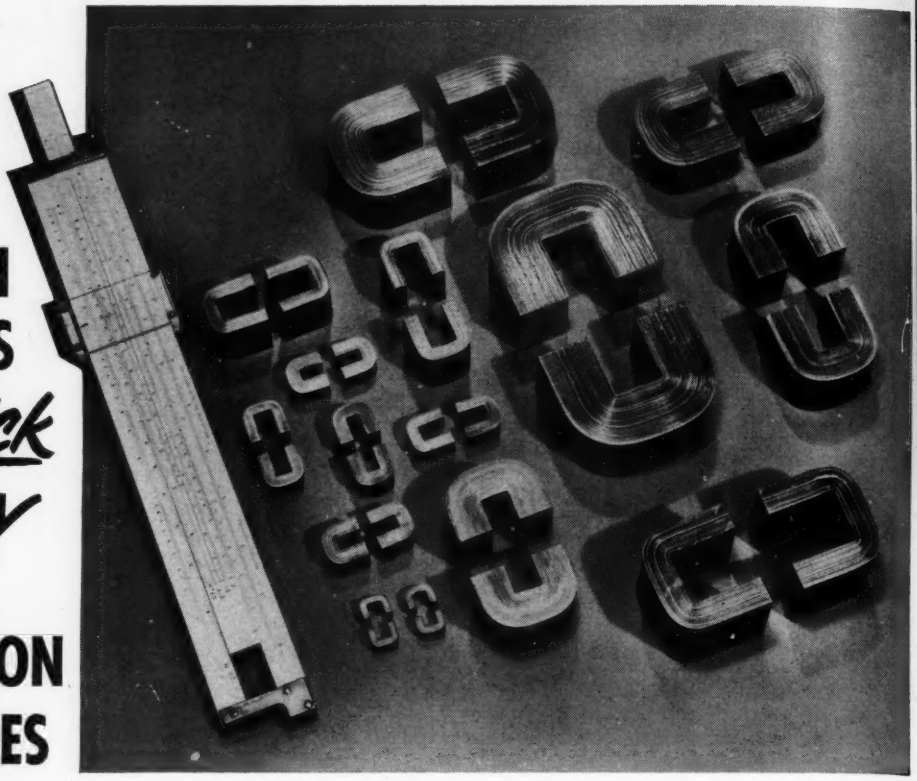
Such characteristics are only part of the picture. Take a look at these additional features:

1. Float type indicator eliminates difficulty in reading meniscus.
2. Adjusting knob provides for temperature compensation over a range of 30° C.
3. Precision bore manometer tube provides accuracy with interchangeability.
4. Fixed cistern type manometer requires only one reading.
5. Mercury sealed valve permits evacuating the tube simply and easily at the point of use.
6. Flexible design permits measurement of absolute pressure, gauge pressure, differential pressure, and vacuum.

For more details, write today for free technical bulletin TP-29-A.

WALLACE & TIERNAN
PRODUCTS, INC.
ELECTRICAL MECHANISMS AND PRECISION INSTRUMENTS
Belleville 9, New Jersey • Represented in Principal Cities

SILECTRON "C" CORES *for quick delivery* IN PRODUCTION QUANTITIES



. . . wound from strip as thin as 0.00025"

Quality-Tested and Proved

- ★ Arnold "C" Cores are made to highly exacting standards of quality and uniformity. Physical dimensions are held to close tolerances, and each core is tested as follows:
- ★ 29-gauge Silectron cut cores are tested for watt loss and excitation volt-amperes at 60 cycles, at a peak flux density of 15 kg.
- ★ 4-mil cores are tested for watt loss and excitation volt-amperes at 400 cycles, at a peak flux density of 15 kg.
- ★ 2-mil cores are tested for pulse permeability at 2 microseconds, 400 pulses per second, at a peak flux density of 10 kg.
- ★ 1-mil cores are tested for pulse permeability at 0.25 microseconds, 1000 pulses per second, at a peak flux density of 2500 gauss.
- ★ ½ and ¼-mil core tests by special arrangement with the customer.

Now available—"C" Cores made from Silectron (oriented silicon steel) thin-gauge strip to the highest standards of quality.

Arnold is now producing these cores in a full range of sizes wound from ¼, ½, 1, 2 and 4-mil strip, also 29-gauge strip, with the entire output scheduled for end use by the U. S. Government. The oriented silicon steel strip from which they are wound is made to a tolerance of plus nothing and minus mill tolerance, to assure designers and users of the lowest core losses and the highest quality in the respective gauges. Butt joints are accurately made to a high standard of precision, and careful processing of these joints eliminates short-circuiting of the laminations.

Cores with "RIBBED CONSTRUCTION"* can be supplied where desirable.

Ultra thin-gauge oriented silicon steel strip for Arnold "C" Cores is rolled in our own plant on our new micro-gauge 20-high Sendzimir cold-rolling mill. For the cores in current production, standard tests are conducted as noted in the box at left—and special electrical tests may be made to meet specific operating conditions.

• We invite your inquiries.

*Manufactured under license arrangements with Westinghouse Electric Corp.

WAD 4211

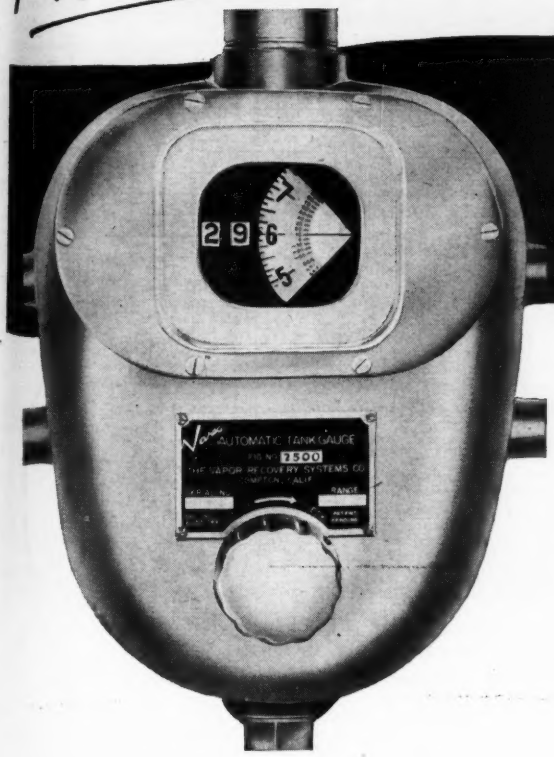
THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois

A New Achievement

.... in simplified, automatic Tank Gauging



"Varec" FIGURE NO. 2500 AUTOMATIC **TANK GAUGE**

FOR ALL TYPES OF LOW PRESSURE TANKS
READINGS UP TO 70 FT.

"VAREC", a pioneer in the development and manufacture of automatic tank gauging equipment has applied new fundamentals of design and operation to the Figure No. 2500 Gauge for the ultimate in accurate liquid level reading and dependable, trouble free operation.

Representing a major improvement with this new concept of simplified automatic tank gauge design, the "VAREC" Figure No. 2500 now utilizes the revolutionary Neg'ator Motor (Pat. No. 2,063,799) housed within the gauge head, to maintain a predetermined constant tape tension. This eliminates the need for a conventional counterweight.

Here's a Look Box You Can Read Easily, Accurately!

(Shown approximately ⅔ actual size)

EASIEST TO INSTALL because:
Both counterweight and counterweight pipe have been eliminated. This permits installation of the look box at any desired height from the ground or on top of tank.

EASIEST TO READ because:
Full view Counter in the Look Box for quick, accurate reading of foot increments and a dial for reading inches and fractions. Use of large distinct numerals minimizes chance of reading errors. Eliminates calibrated tape.

EASIEST TO OPERATE because:
"VAREC" patented Gravity Compensator (Pat. No. 1879805) is incorporated with "inch reading" dial. An external Gauge Check device (Pat. No. 2555593) permits manual checking of gauge operation when desired.

EASIEST TO MAINTAIN because:
All internal parts of the Figure No. 2500 Look Box are non-sparking in contact with each other.
Non-corrosive Graphitar tape sheave bearings — self lubricating.

The "VAREC" Figure No. 2500 Automatic Tank Gauge is gas tight. It is adaptable to all types, arrangements and installations of low pressure tanks up to 70 feet in height. "VAREC" Figure No. 2500 Gauge Head is available as a separate unit and can be installed on existing float operated type tank gauges utilizing ½" wide tape sheaves.

Provision has been made on the Look Box housing for installation *at any later date* of a "VAREC" Electronic Remote Reading Gauger Transmitter for use in conjunction with the various models of "VAREC" Electronic Gauger Receivers.

If you are not yet realizing the many time and money saving features and advantages of automatic tank gauging in your operations, install this new, simplified "VAREC" Figure No. 2500 Automatic Tank Gauge and start out ahead. Write or call your nearest "VAREC" Representative for all the facts.

"Varec" PROVED and APPROVED

THE VAPOR RECOVERY SYSTEMS COMPANY
2820 N. Alameda Street, P. O. Box 231
Compton, California, U.S.A.

MAIL COUPON NOW FOR NEW BULLETIN CP-3500

THE VAPOR RECOVERY SYSTEMS COMPANY
2820 N. Alameda Street, P.O. Box 231
Compton, California, U.S.A.

Dept. _____

Name _____ Title _____

Street and No. _____

City and State _____

For versatility in **FORCE MEASUREMENT**

use the HAGAN

air-operated THRUSTORQ

The Hagan THRUSTORQ translates a force or weight into a pneumatic signal pressure. This pressure reports the force or weight accurately and dependably to indicating or recording instruments, or to an automatic control system.

Some typical applications of Hagan THRUSTORQ include:

- testing piston rings
- jet engine thrust measurement
- rocket thrust measurement
- spring testing machines
- automatic batch weighing
- dynamometer testing of electric motors, hydraulic pumps or internal combustion engines

HAGAN THRUSTORQ
measuring thrust and torque *with air!*

HAGAN
HALL
BUROMIN
CALGON

For information about the application of Hagan THRUSTORQ to your particular problems, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

Figure...First!

Yes . . . it pays to figure *first* . . . instead of afterward . . . how Veeder-Root Counters can profitably be *built into* your new products, machines, or processes . . . to build up sales appeal and new markets.

Much easier to call in a Veeder-Root engineer *now*, than waiting until *later*, when your design is in production.

And remember that you can count on Veeder-Root to help you, consistent with defense commitments.

VEEDER-ROOT INCORPORATED

"The Name That Counts"

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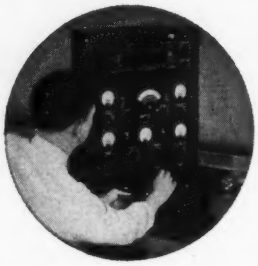
Chicago 6, Ill. • New York 19 • Greenville, S.C. • Montreal 2, Canada
Dundee, Scotland • Offices and Agents in Principal Cities

TEST EQUIPMENT by WESTON

for ALL electronic and electrical maintenance needs!

Mutual Conductance ELECTRONIC TUBE ANALYZER

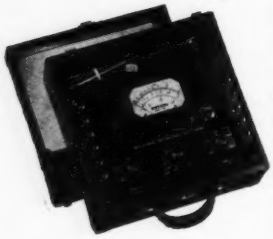


(Model 686) an "all purpose" tube analyzer that tests tubes under exact operating potentials. Accurately determines true mutual conductance of all tubes both in accordance with manufacturer's rated operating conditions, as well as at other values for non-standard applications.

High Frequency ELECTRONIC ANALYZER (Model 769)

three instruments in one: a Volt-Ohm-Milliammeter with self-contained power source—a high impedence electronic Volt-Ohmmeter using 115 volt 60 cycle power—a stable, probe type Vacuum Tube Voltmeter for use to 300 megacycles.

Multi-Purpose CIRCUIT TESTER



(Model 785) a versatile, portable tester for laboratory or maintenance needs, where an ultra-sensitive instrument is required. Provides 28 A-C and D-C voltage, A-C and D-C current, and resistance ranges. (D-C sensitivity 20,000 Ohms per volt.)

Mutual Conductance PORTABLE TUBE CHECKER

(Model 798) for general testing of all receiving tubes, voltage regulator tubes and low power thyratron tubes. Provides proportional mutual conductance ranges 3000/6000/12000 micromhos. Compactness and light weight make it ideal for all servicing requirements.

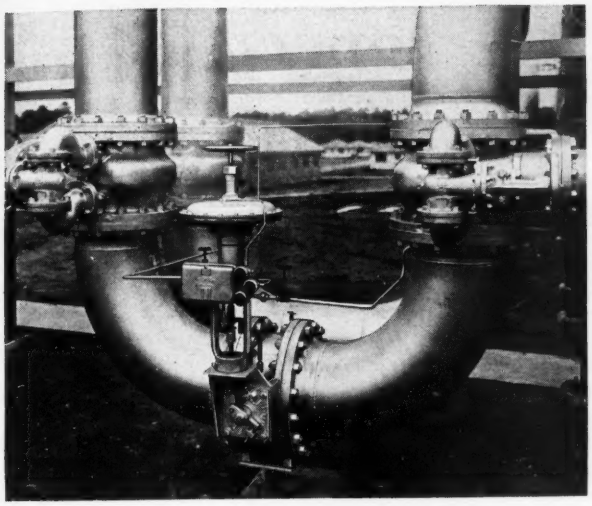
All WESTON Test Equipment is specifically designed to provide time-saving facility and increased efficiency for all electronic or electrical maintenance jobs. For complete information on all equipment in this broad line, consult your nearest WESTON representative, or write for Test Equipment Bulletins . . . WESTON Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey . . . manufacturers of Weston and TAG Instruments.

WESTON *Instruments*

9567

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



▲ **R-S Automatic Valve installed on water jacket to gas engine in gas booster station.**

WIDE RANGE of Application

R-S Valves are used in air, gas, liquid, steam, and semi-solid service for the shut-off and regulation of volume and pressure, pressure relief, liquid level control, back pressure, water hammer, steam hammer, constant differential pressure, and the output control of pumps, fans, engines and turbines. Suitable for service in the temperature range from minus 300° to plus 2000° F. 2 to 2500 psig.

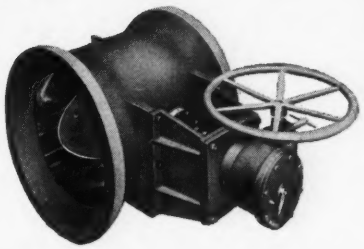
Simplicity of design, ease of operation, positive rubber seat shut-off, and the wide range of application indicate the high order of metallurgical and mechanical engineering that is embodied in every R-S valve.

Consult your local R-S Valve Engineers, or write direct.

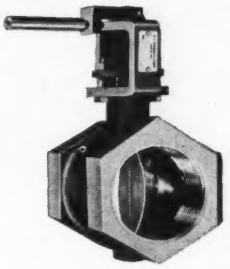
R-S PRODUCTS CORPORATION
4600 Germantown Avenue, Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES

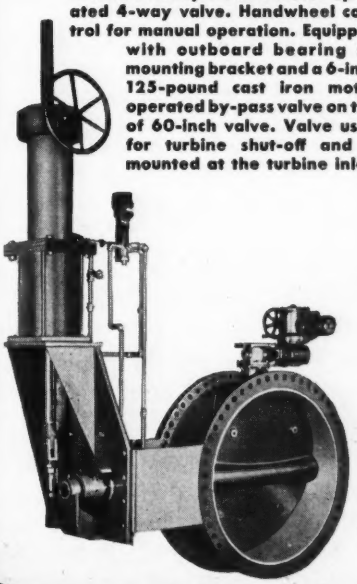


No. 836—24-inch 125-pound cast iron hub-end valve with bronze liner and monel periphery on vane for water service. Equipped with totally enclosed gear reducer, handwheel and locking device.



No. 801—3-inch 125-pound bronze screwed-end valve with handlever control and locking device.

No. 828—60-inch 150-pound cast steel valve with 18-8 shafts, bronze bushings and bronze body liner. Cylinder operator is controlled by electric motor operated 4-way valve. Handwheel control for manual operation. Equipped with outboard bearing on mounting bracket and a 6-inch 125-pound cast iron motor operated by-pass valve on top of 60-inch valve. Valve used for turbine shut-off and is mounted at the turbine inlet.



A Respectful Suggestion

to *Instruments* Readers who are concerned with Advertising and Sales

Subject: Advertising in *Instruments*

The great majority of *Instruments* readers are buyers or users of instruments; they are not employed by instrument manufacturers.

Instruments is an excellent advertising medium for the instrument companies and for many manufacturers of other products.

We know full well that it would hardly pay a candy or cosmetics or carpet company to advertise in *Instruments.*

YOU know that you and other typical readers, who don't specify candy or cosmetics for your companies, do specify—and do buy—many products: not only instruments but accessories.

If you USE products made by your own company, it stands to reason that SOME other instrument users BUY them—and that ALL instrument users are prospective buyers.

Hence this suggestion.

* * *

We specifically suggest that you insert an advertisement in the next issue of *Instruments*—the August 1952 issue—because:

(1) It is the famous "Pre-Show" Issue, containing as usual the advance information on the National Instrument Conference and Exhibit, to be held this year in Cleveland September 8-12.

(2) Appearing three weeks before the Show, the August issue will be read eagerly for the latest information on commercially-available products—products exhibited at Cleveland AND products not exhibited but advertised in the August issue.

(3) Circulation: 14,081 net paid subscribers; plus several hundred as usual to meet various present and future requirements; PLUS 2000 EXTRA COPIES TO BE DISTRIBUTED AT CLEVELAND.

* * *

CLOSING DATES: For copy, Monday, July 21; for complete plates, Friday, July 25.

* * *

MECHANICAL REQUIREMENTS

	Width	Depth
Full page	42 picas	60 picas
Two-thirds page	27 picas	60 picas
Half page (hor.)	42 picas	29 picas
Half page (vert.)	20 picas	60 picas
Half page (island)	27 picas	44 picas
Third page (sq.)	27 picas	29 picas
Third page (vert.)	13 picas	60 picas
Quarter page	20 picas	29 picas
Sixth page (vert.)	13 picas	29 picas
Sixth page (hor.)	27 picas	14 picas

Halftones, 110 screen

Trim size 8¼ x 11¼ inch

Bleed plates 8⅜ x 11½ inch

The advertiser agrees to indemnify and protect the publisher from any claims or actions based upon the unauthorized use of any person's name or photograph, or of any sketch, map, words, labels, trademarks, or other copyrighted matter, or based upon libellous statements, in connection with the advertising referred to in this order.

All engravings, electrotypes, etc., may be destroyed by publisher if not requested within a year after last use.

For addresses and telephone numbers of District Representatives, see page 830 (this issue).

Instruments Publishing Co., Inc.
921 Ridge Avenue
Pittsburgh 12, Penna.

Here's why it pays to know your HSM

HONEYWELL SUPPLIES MAN

This butt-welded thermocouple is faster because: (1) Butt-welding replaces mass of metal at hot junction; (2) Shape of wire prevents insulator from dissipating heat and affecting response.

J. F. KRAMER, Honeywell Supplies Man in the Cleveland area, tells Mr. George Taylor of the S. K. Wellman Co. all about the new Brown butt-welded thermocouple . . . after describing the benefits of the HSM Plan for buying pyrometer supplies.

You'll be pleasantly surprised when *you learn* how *the plan* can add new convenience and economy to your pyrometer supplies purchasing, too!

There's a Honeywell Supplies Man near you . . . at your local Honeywell office . . . no further away than your phone. Call him in today, and you'll take an easy step in the right direction.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa. Stocking points in Philadelphia, Cleveland, Chicago, Atlanta, Houston, Los Angeles and San Francisco.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

● *Important Reference Data*

Write for Specification Sheet No. 306 on the butt-welded thermocouple . . . and for new Pyrometer Supplies Buyers' Guide No. 100-4.

Why Resistance-thermometer Bridges can serve you

Use of a modified Wheatstone bridge for temperature measurements provides several characteristics of value in a variety of laboratory procedures.

One characteristic, of course, is ability to reach highest precision; here the equipment is unique and becomes a "must". However, other characteristics give the scientist options in other connections. Perhaps the sometimes higher cost, the larger size of resistance-thermometer units as compared with thermocouples and the relative slowness as compared with 20-gauge or finer thermocouples, have obscured such advantages as the following:

Wide Range. A temperature bridge with appropriate thermometers can cover as much or as little as you wish of the temperature range from −258 to +660 C . . . that is, from below the hydrogen point to above the antimony point. Furthermore, the instrument measures actual temperature . . . not temperature difference as a thermocouple does. This combination of values indicates usefulness for routine work as well as for secondary and primary standards.

Readability. The reading device for a bridge measurement moves several times further per degree C than is the case with other instruments. For example, with a Mueller Bridge the galvanometer spot moves 2 mm per 0.001° C; whereas with a thermocouple and a White or Wenner potentiometer the spot moves 0.7 mm, and a Beckmann differential thermometer's mercury column moves only 0.1 mm per 0.001° C. Other instruments of the three classes may show larger motions, but differences will be of the same order. Thus, the bridge method has outstanding advantages in readability.

"Average" Readings Supplied. The sensitive portion of a resistance thermometer is about as large as a mercury thermometer's bulb, whereas the sensitive area of a thermocouple is perhaps 1 or 2 mm sq. The resistance unit thus averages the temperature of an appreciable area, reducing the effect of non-uniformity in ambient fluid.

Sturdiness. Industrial-type resistance thermometers (Thermohms) are as sturdy as thermocouples and are installed in the same way. Among laboratory-type equipments, the most fragile resistance unit stands up quite definitely better than mercury bulbs under the small shocks and impacts which even the most careful user will impose. Furthermore, a broken or damaged resistance unit's case can often be replaced or repaired. These very practical advantages lead many scientists and test engineers to use the bridge method.

Remote Reading. Bridge instruments are inherently remote-reading; there is no need to consider accessibility, lighting, etc., of the primary element. This advantage is a real one, even when making small set-ups of equipment. On large or intricate set-ups, where vessels may be at various levels, and protection from light, body heat, etc., are possible additional factors, bridge measurements are often the only practical method.

Principal Characteristics of L&N Temperature Bridges

Instrument	No.	Arrangement of Ratio Arms & Rheostat	Limit of Error
Type G-2 Mueller Bridge (Extreme high precision) Accessories needed: Precision Resistance Thermometer; H S Galvanometer	8069	Two ratio arms, 1000 Ω ea., adjustable to equality. Rheostat range 0 to 111.111 Ω in 0.0001 steps. Three shunted decades giving steps of 0.0001, 0.001 and 0.01 Ω; three decades of 0.1, 1 and 10 Ω resistors. Principal shunted and decade resistors thermostat controlled to 0.01 C	Certification by NBS recommended at extra cost. Limit of error is a few ten thousandths of an ohm or a few parts in a hundred thousand whichever is larger, provided a recently determined bridge calibration correction is applied.
Type G-1 Mueller Bridge (Excellent Precision) Accessories needed: Same as for Mueller Type G-2	8067	Two ratio arms, 500 Ω each, adjustable to equality. Rheostat range 0 to 81.111 Ω in steps of 0.0001 Ω. Three shunted decades giving steps of 0.0001, 0.001, 0.01 Ω; two decades at end of ratio arms of 0.1 and 1 Ω resistors, and binding posts on end of rheostat for connection of 0, 10, 20, 25, 25.5, 30, 40, 50, 60 or 70-Ω resistors.	±0.02% or a few ten thousandths of an ohm whichever is greater.
Resistance-Thermometer Bridge (Moderate Precision) Accessoriesneeded:Thermohm Resistance Thermometer; Galvanometer	8063	Two ratio arms, 130 Ω nominal. Rheostat range 0 to 200.1 Ω. Two dial decades 9 (1 + 10) Ω, and a 100-Ω resistor removable by short-circuiting link, plus adjustable slidewire of 1.1 Ω.	±0.005 Ω up to 10 Ω ±0.05% above 10 Ω
Portable Temperature Bridge Accessory needed: Thermohm Resistance Thermometer	8062	This instrument is No. 8063 in portable form; all electrical characteristics are the same.	
Portable Temp. Indicator Accessory needed: Thermohm Resistance Thermometer	8015	Range As specified, for type of Thermohm specified	±0.3% of range
Portable Temp-Difference Indicator. Accessories needed: Matched pair Thermohm Resistance Thermometer	8025	Range 0 to 20 F temperature difference for any specified 20 F interval between the limits of 0 and 200 F	±0.1 F

For further particulars of any of the above equipments address our nearest office or 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP

Jrl Ad EF2(3)

Editorial Comment

Plan Your Trip to Cleveland Now!

EVERY reader of these lines who can be in Cleveland, Ohio, in September should plan to do so and should make certain of transportation and hotel reservations. The Cleveland Auditorium will be the scene of:

(1) The Seventh Annual American Instrument Exhibit, under the auspices of The Instrument Society of America.

(2) The Seventh Annual Conference of the ISA, consisting of twenty-six technical sessions;

(3) Technical sessions on Instrumentation topics, featuring a High-Pressure Symposium, arranged by the Industrial Instruments and Regulators Division of the American Society of Mechanical Engineers;

(4) Technical sessions on Instrumentation topics, arranged by the Instruments and Measurements Committee of the American Institute of Electrical Engineers;

(5) Technical sessions on Instrumentation topics, arranged by the American Institute of Physics;

(6) The usual three-day Preconference Instrument Maintenance Clinic (Sept. 5, 6 and 7), arranged by the ISA (At Case Institute—NOT at Auditorium);

(7) New this year: a three-day Clinic on Analysis Instrumentation, also arranged by the ISA.

We don't have to prod the ISA members among our readers: they've been receiving programs, hotel lists, airline and railroad sales letters, bus charter terms, etc.

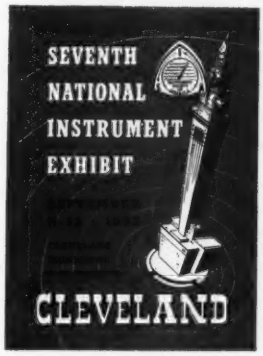
And—no doubt—readers who belong to the ASME, AIEE and AIP have also been circularized.

So it is to the majority of our readers—the non-members—that we aim to convey some of the enthusiasm we've caught from several ISA officials. This enthusiasm on the part of ISA officials is justified by the excellence of the programs of all participating societies, by the record-breaking number of commercial exhibits, and by the large figures of promised attendance from all geographical sections.

The ISA's technical program alone should draw thousands of men from all major occupational fields. It is rich, diversified and full of up-to-the-minute subjects. This year the ISA will hold no fewer than twenty-six sessions! Here is a brief summary:

One general session; Production processes Instrumentation, 5 sessions; Testing, 6 sessions; Analysis, 2 sessions; Maintenance and Operation, 2 sessions; Inspection and Gaging, 1 session; Medical, 3 sessions; Aeronautical, 3 sessions; Geophysical, 1 session; Radiation, 1 session; Meteorological, 1 session.

As we go to press we don't know the total number of sessions to be held by the cooperating societies; but what's certain is that every morning, afternoon and evening there will be more events than one man can take in.



Therefore, it behooves the management of every interested company and institution to send as many men as possible.

Let every top management emulate the top management of Shell Oil which, for the last six years, has not merely ALLOWED but ENCOURAGED and DIRECTED the Shell instrument engineers (from the U. S., Canada, West Indies and Europe) to attend the annual Instrument Conferences and Exhibits—and to remain in the Conference city each year for a total of ten or twelve days to exchange ideas and compare notes!

If this pays one oil company, it should pay all other oil companies—and all companies that are being instrumentized.

Every reader who has attended a previous ISA Conference and Exhibit knows that there's little or no time for carousing: thirty-odd sessions; various committee meetings; two maintenance clinics . . . AND the Exhibit itself, with the record-breaking number of 176 exhibitors—many of them disclosing radically new products. Every technical reader should plan now—not only to be allowed to go but to be ordered to go. Every executive reader should plan to go and to take along some of his company's technical men.

—M.F.B.

Control Valves

THIS and the next two months' issues will conclude the series of control-valve articles based on papers presented at the Symposium "The Use and Application of Control Valves" held last April by the New Jersey Section of the ISA. The special significance of this group of articles lies in the fact that all the authors* are outstanding control-valve specialists. Their articles present the latest developments in the valve field and—of great importance—the latest techniques by which various authorities select and size valves for specific applications. *Instruments* is proud to have rendered the service of bringing this wealth of up-to-the-minute information to its readers.

*R. Milham and A. Catheron of Foxboro; G. F. Brockett of Fisher Governor; R. Rockwell of Mason-Neilan; O. Kneisel of Hammel-Dahl; and D. Eckman of Conoflow.

Maintenance

THE series of articles on the Los Angeles Harbor Junior College "Instrument Maintenance Short Course" continues in this issue with J. Witherspoon's article on "Electronic Recorders." Coming in this important series are "Maintenance of Pressure Recorders" by R. F. Fields; "Gas-pressure Regulators" by W. L. Masheter; "Electrolytic Conductivity Measurements" by G. F. Rucker; "Orifice Coefficients" by G. H. Forster; "Gravity Recorders" by J. M. Quirk; "Displacement Meters" by P. Renfrew; and "Recording Calorimeters" by B. Cossey. This group of articles emphasizes subjects of great interest to the maintenance men among our readers.

Process Industries

THE August issue also begins the papers presented at the Seventh Symposium on Instrumentation for the Process Industries held at Texas A & M College in June 1952, which papers have gained world-wide recognition for their quality. We are pleased to announce that all the papers presented at this Symposium will appear in *Instruments*.

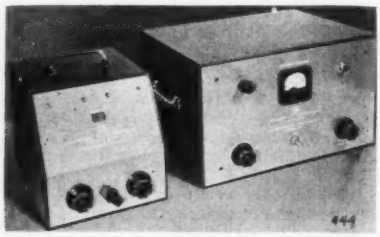
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 943

Nuclear-resonance-type Magnetometer

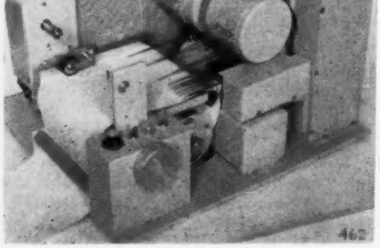
New "Model 101 Magnetometer" measures magnetic field strength with highest attainable accuracy by using principle of nuclear resonance; is first commercially-available instrument of its type. An oscillatory magnetic field is provided by means of a coil surrounding a sample which permits measurement of proton resonance and nuclear resonance of lithium-7. Coil is part of an oscillator so designed that its level of oscillation drops with an increase in circuit losses, such as may be introduced by nuclear resonance in sample material. This resonance is easily viewed on an oscilloscope. Range of field strength measurements, 300 to 25,000 gauss, covered by proton and lithium resonances, by a frequency spectrum of 1.18 to 34 Mc. Instrument's use is limited to measurement of magnetic fields whose homogeneity is at least one part in 500 for proton resonance and one part in 5000 for lithium resonance over dimensions of sample to be detected. Sample material area approx. 0.3 sq. cm.—*Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.*



Mention No. 701 when filling out card.

Nine-stylus Recorder

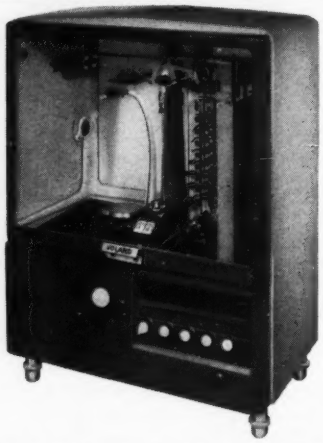
New "Type R03-E6-1" multi-channel system provides nine channels for direct recording of transient phenomena; is suited for telemetering problems requiring a 0-20-cps. flat frequency response. Three signal channels utilize a 40-mm. chart grid width; five channels are supplied for off-on functions and one is assigned to an integral time pulse generator. Among features: stylus motor system which permits operation in any plane; six-speed semi-automatic chart drive, and automatic reroll mechanism.—*Rahm Instruments Inc., 12 West Broadway, New York 7, N. Y.*



Mention No. 702 when filling out card.

High-precision Balance

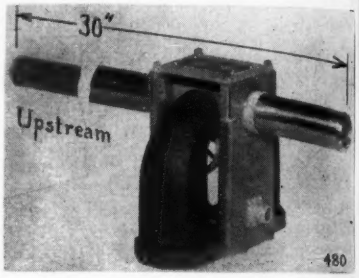
New "Voland Universal Balance," for weighings to 200 grams, is said to be "a completely new instrument, inside and out." Among features: (1) A projection system of unusual stability whereby projection readings can be made with accuracy of best non-projection analytical balances and results obtained as fast as those of any balance now on the market. (2) An exclusive mechanism that raises sensitivity, permitting positive readings to eight significant figures, for example, 180.43265. (3) New beam system with features never before manufactured in U. S., whereby weighing results far exceed accuracy now available "in any of the best standard analytical balances." (4) New cabinet: All mechanisms and knobs attached to a chassis which can be moved easily in and out of cabinet and do not depend on any part of cabinet for support; projection system built into one complete compact unit; glass base plate floats and acts merely as a floor of balance. (5) New front door eliminates counterweights and any spring adjustments: "quietest and smoothest working door yet developed." (6) Mechanical construction basically simple; balance is easily set up and easily maintained.—*Voland and Sons, Inc., P.O. Box 680, New Rochelle, N. Y.*



Mention No. 703 when filling out card.

Magnetic Flowmeter for Molten Metal

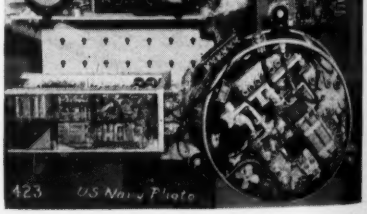
New magnetic flowmeter, for remote measurement of molten-metal flow, has its primary element external to flowing liquid; consists essentially of a permanent magnet with a pipe centered between magnet pole faces by means of stainless-steel supports. Flow of molten metal through pipe cuts magnetic lines of flux set up by magnet, generating a small direct voltage in pipe proportional to magnetic flux and to rate of metal flow. Any potentiometer-type indicating or recording instrument can be used to measure this millivolt output. Primary element is 3 x 5.25 x 6 in. and will accommodate flow in pipe sizes of 0.5, 0.75 or 1 in. Accuracy is 3 percent. —*General Electric Co., Schnectady 5, N. Y.*



Mention No. 704 when filling out card.

Collision-warning Radar System for Aircraft

New "APS-42" lightweight (250-lb.) radar set, already installed on President Truman's *Independence* and on military air transports, "maps" every detail of terrain and weather obstacles up to 200 miles in front of an aircraft;



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

Have you a copy of the Jan. 1928 *Instruments?*

(or, perhaps, of all twelve issues of Vol. 1—Jan.-Dec. 1928?)

Yes, we know that there are unmutilated copies of Vol. 1—and all subsequent volumes—in libraries; but we are after *individual owners.*

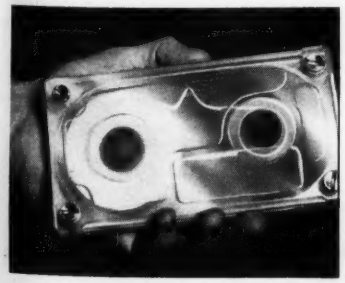
Please write to Historical Section, The Instruments Publishing Company, 921 Ridge Avenue, Pittsburgh 12, Penna.

is said to be first system of its kind to go into production that has both military and commercial application. At pilot's selection, signal from radar antenna can be transmitted either as a pencil beam for obstacle detection and general search, or as a vertical fan for mapping and navigational aid. Equipment is also designed to supplement landing approach equipment by picking out airfields and, under certain conditions, runways. In addition, it provides pilot with a visible check of other landing and approach instruments in plane, and with any directions that he may receive by radio from GA officer. Antenna is mounted on a platform (upper right) stabilized by a gyroscope so that signal is unaffected by plane's pitch and roll.—*RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Mention No. 705 when filling out card.

Operation-time Recorder

New extremely-simple basic recorder facilitates monitoring and obtaining definite information in traffic, time and motion study, punch press operation, duration of current flow, stresses and strains, weather information—"practically anything that varies." No pen or ink, photographic delay, inertia or delicate moving parts: new "Alfax" direct-recording paper. Magazine unit consists of recording electrodes, timing switch and paper reels. Reels hold 8 days' supply of "Alfax" paper. Driving unit contains a synchronous motor to drive one of paper reels; has 4 resistors and a rectifier tied into 110 v.a.c. line



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

For Performance, Durability and Economy
Choose the Welch
LARGE CAPACITY TWO-STAGE DUO-SEAL®
VACUUM PUMP

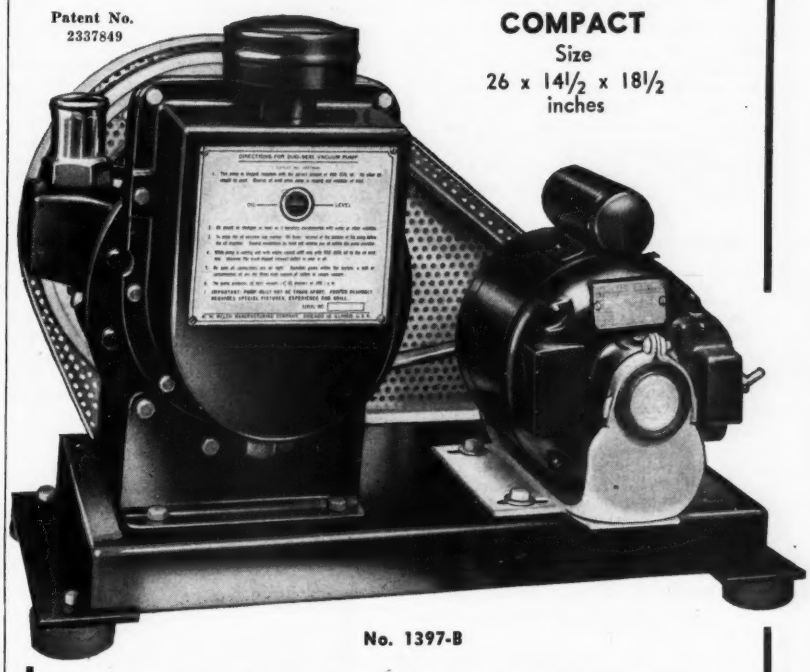
HIGH VACUUM
.0001 mm (0.1 Micron) Guaranteed

Exceptionally Quiet Operation
Built-in Trap prevents oil from backing up into system.

Indicator window shows oil level at all times.
Convenient oil drain permits oil change without dismantling system.

Patent No. 2337849

COMPACT
Size
26 x 14½ x 18½ inches



No. 1397-B

TIME REQUIRED TO EVACUATE INDICATED VOLUME TO VARIOUS PRESSURES

PRESSURE mm of Hg		Microns	EVACUATED VOLUME IN LITERS				
			5-L.	10-L.	25-L.	50-L.	100-L
			MINUTES	MINUTES	MINUTES	MINUTES	MINUTES
100	—	1000	.13	.28	.68	1.4	3.0
10-1	—	100	.18	.38	1	2	4.2
10-2	—	10	.26	.53	1.40	3.00	6.10
10-3	—	1	.40	.80	2.10	4.26	9.00
10-4	—	0.1	.61	1.23	3.15	6.37	13.90

COMPLETE $515.00

W. M. WELCH SCIENTIFIC COMPANY
Established 1880
1515 SEDGWICK STREET, DEPT. B — CHICAGO 10, ILLINOIS, U. S. A.
Manufacturers of Scientific Instruments and Laboratory Apparatus

through a detachable line cord. For convenience in laboratory, signal circuits have test point jacks.—*Alden Electronic & Impulse Recording Equipment Co. P.O. Box 125, Westboro, Mass.*

Mention No. 706 when filling out card.

Control Pyrometer

New "U-Mount-It Simplytrol" automatic controller consists of wire-connected components, of which only contact-making millivoltmeter shows on

panel. This indicating-controlling instrument is available in 2.5-, 3.5- and 4.5-inch sizes; it will control on less than one microampere or a fraction of a millivolt. Equipment includes all relays for controlling 15 amps. at 115 volts non-inductive load.—*Assembly Products Inc., Chagrin Falls, Ohio.*

Mention No. 707 when filling out card.

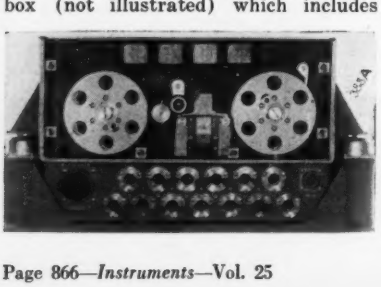
Miles-per-gallon Indicator

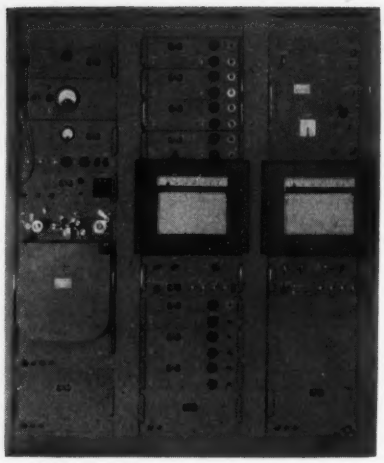
New "Henstrometer" shows miles-per-gallon of gasoline simultaneously with usual speedometer reading of miles-per-hour. Spacing of dial numbers on conventional speedometer face is "improved to give easier and more accurate reading" of miles-per-hour at normal driving speeds; and a shorter hand "indicates on the same dial the number of miles per gallon actually being obtained while the car is in motion."—*H. G. Strong & Associates, 133 Edwards Drive, Fayetteville, N. Y.*

Mention No. 708 when filling out card.

Magnetic Tape Recorder and Analyzer System

New low-frequency magnetic-tape data recording, playback and analysis system, originally developed for study of vibration in aircraft, is suitable for a variety of industrial and research applications. Typical components: (1) "Model 501" magnetic-tape recorder (Fig. A) records 14 channels on 1.75-in. tape. One channel carries an internally generated timing wave. Equipment is operated from a remote control box (not illustrated) which includes





means for establishing amplitude of calibrating voltage. (2) "Model 502" playback system (Fig. B, left-hand panel) is a group of rack-mounted units designed to play back tapes recorded by "Model 501" and accurately reproduce original data. (3) "Model 510 Automatic Wave Analyzer" (Fig. B, right-hand panels) produces plotted analyses of tape-recorded data; selects pair by pair until all twelve output channels have been analyzed and recorded on ten-inch strip-chart of potentiometer with special slidewire giving 40-db logarithmic response over 8 inches of chart and linear below to zero. Four chart rates automatically selected.—*The Davies Laboratories Inc., 4705 Queensbury Rd., Riverdale, Md.*

Mention No. 709 when filling out card.

Humidity Controller

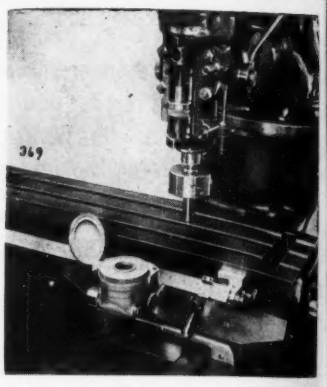
New "Electronic Humidity Control" provides two-position or proportioning, humidifying or dehumidifying, for process or comfort control; features

plug-in element and simple adjustments. Moisture-sensitive element is said to change resistance "instantly with minute changes in relative humidity." In spaces supplied by a central fan, primary element is mounted either in duct or conditioned space, remote from amplifier and adjustments. For controlling relative humidity in spaces not completely air-conditioned, highly-sensitive aspirating type control is available with all operating adjustment mechanisms mounted in a cabinet.—*Barber-Colman Co., Rockford, Illinois.*

Mention No. 710 when filling out card.

Optical Positioner for Machine Tools

New "Scan-A-Scale" provides optical method of making linear measurements on machine tools; is said to eliminate need for micrometers, loose standards and dial indicators. It consists of two microscopes and two scales graduated



in 50 thousandths of an inch. By rotating a dial on microscope, the 50 thousandths graduation on scale can be divided so that readings to four decimal places are determined. Uses include: positioning lathe carriages longitudinally; locating milling machine table in respect to spindle in all three planes; etc.—*F. T. Griswold Mfg. Co., Wayne, Penna.*

Mention No. 711 when filling out card.

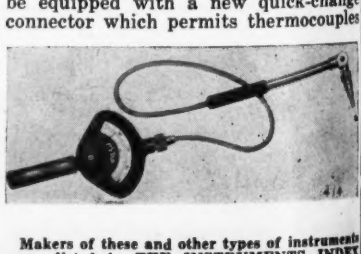
Sealed-package Hygrometer

New relative humidity indicator helps safeguard packaged military equipment from rust and corrosion during long storage periods; was developed in cooperation with Department of Defense and tested under Ordnance Corps. Primary element, about matchbook size, is made of plastic, embossed on one side with a gold-leaf grid coated with a hygroscopic film whose conductance changes with relative humidity. Element can measure presence of one-half a tablespoon of water in an average-size living room (12 by 18 feet). When installed in packages, it is connected to an external plug by leads that extend through a vapor barrier. Humidity in package is read on a specially-designed electrical instrument plugged into external connection.—*Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Mention No. 712 when filling out card.

Surface Pyrometer

New "Pyro Surface Pyrometer" for surface and sub-surface temperature measurements is available in 5 ranges and with a selection of 14 types of thermocouples and extension arms; and can be equipped with a new quick-change connector which permits thermocouples

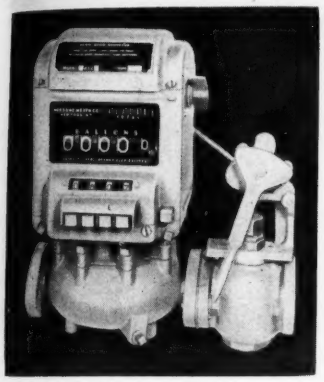


to be snapped and locked onto extension arms in about one second, without tightening. Thermocouples are interchangeable without adjustment or recalibration.—*Pyrometer Instrument Co., Bergenfield, N. J.*

Mention No. 713 when filling out card.

Preset-volume Meter

New "Auto-Stop" meter automatically controls quantity of industrial liquids fed into processes or batching operations; consists of "Model 432 Auto-Stop" register mounted on "Type S" disk meter and coupled to a quick-closing valve. Operation: tripping mechanism is first set by pushing buttons on register until number of gallons desired shows up on numeral wheels just above buttons; register is then cleared back to zero; and valve is opened. Large numerals keep pace with flow and provide a visual check when delivery is finished; small shuttered totalizer keeps cumulative totals from which daily, weekly, or monthly figures can be recorded. Flow can be stopped instantly by pressing emergency stop button, without affecting meter reading or Auto-Stop setting. New meter is available in 1, 1.5 and 2 in. sizes, with capacities from 5 to 100 gpm.—*Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.*



Mention No. 714 when filling out card.

Sensitive Diaphragms

New arc-welded diaphragms of extremely thin stainless steel, Ni-Span C, and phosphorus bronze, are available in thicknesses of 0.0015 to 0.005 inch for pressure elements, seals, etc. Specially-developed equipment makes it possible to successfully arc-weld these extremely thin units.—*The Bristol Company, Waterbury 20, Conn.*

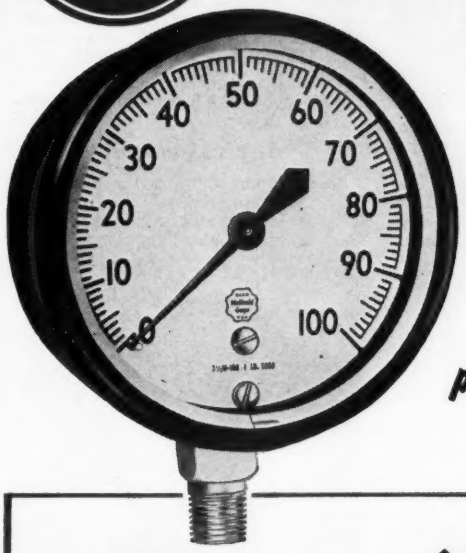
Mention No. 715 when filling out card.

Wired Industrial TV

New "Model 300-B Utiliscope" wired-television system, specially designed for industrial applications, plugs into 105-125-vac. supply, uses image-dissector

an ACCO product

HELICOID



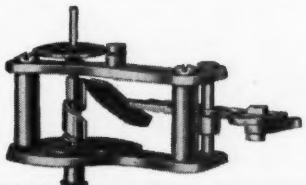
The gage that retains its original accuracy longer, lasts longer, costs less per gage, per year

NOW...a 3½" Gage

Now you can get the popular gearless Helicoid Movement in a 3½" Helicoid Gage for pressures from 100 lbs. to 10,000 lbs. and vacuum, in steel systems, or 15 lbs. to 1000 lbs. and vacuum, in bronze systems. Phenol or ACALOY case. Prominent black letters on white phenol dial. Stem, panel or flush mounting.

The Helicoid Movement is a simple cam and roller design that has no teeth to wear out. Tested and proved in years of hard service. Helicoid Gages give long, trouble-free service with little maintenance.

Only Helicoid Gages have the gearless Helicoid Movement, so look for the name Helicoid.



Write today for the Helicoid Catalog

FOUR HELICOID FEATURES

1. Stainless Steel Helicoid Roller (no gear teeth)
2. Stainless Steel Hair Spring
3. Long Life Cam (no gear teeth)
4. Corrosion Resistant Link and Screws

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE

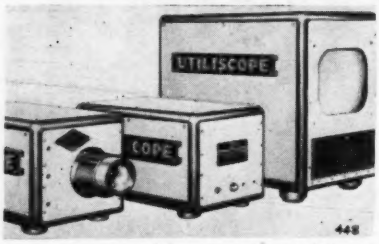
TRADE MARK

929 Connecticut Avenue • Bridgeport 2, Connecticut

HELICOID Pressure • Vacuum GAGES

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

NEW INSTRUMENTS

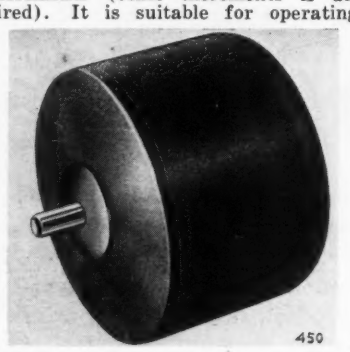


type camera with guaranteed life of one year. Camera and power supply can be 1500 feet from monitor-viewer without need of booster. Camera lens remotely focused from monitor. Resolution 300 lines horiz. & vert.—*Diamond Power Specialty Corp., Lancaster, Ohio.*

Mention No. 716 when filling out card.

Stepping-type Rotary Positioner

New "Roto-Stepper" is a solenoid-operated stepping positioner which can rotate in unlimited clockwise and/or counter-clockwise directions, in 2-degree increments (other increments if desired). It is suitable for operating

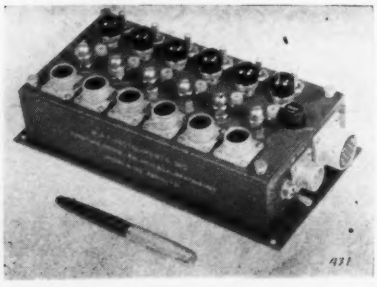


indicators, potential dividers, synchros, switching devices and other low-torque mechanisms. Solenoid operates on 24-volt supply. Stepping maximum is 720 impulses per minute with min. pulse length of 0.05 sec. (up to 30 pulses per second, depending on torque). Torque output varies with pulse rate, approx. 12 in.oz. at 12 pulses per second.—*G. M. Giannini & Co., Pasadena 1, Calif.*

Mention No. 717 when filling out card.

Strain-gage Bridge

New "Model 6-100 Miniature Bridge-Balance and Calibrating Unit" provides means of adjusting and matching any resistance-pickup or strain-gage bridge



to any oscillograph galvanometer for direct recording of strains, loads, accelerations, etc. Features include individual channel adjustment of voltage, balance, calibrating level and phase, and galvanometer damping. Easily-accessible resistor rack accommodates calibrating and series or shunt galvanometer damping resistors. Individual channel control facilitates balancing procedure. Each unit accommodates six channels.—*B & F Instruments, Inc., 1115-15th St.,NW, Washington 5, D. C.*

Mention No. 718 when filling out card.

Angle Computer

New "Model G" Studler Angle Computer is improved version of "Model B," for layout and inspection of jigs, dies, fixtures, patterns, castings, etc.

All three 360-degree protractors are accurate within seven seconds of arc; all three verniers read to one minute of arc. Weight, approx. 530 lbs.—*The Angle Computer Co.,* 1709 *Standard Ave., Glendale* 1, *Calif.*

Mention No. 719 when filling out card.

Servo Amplifier

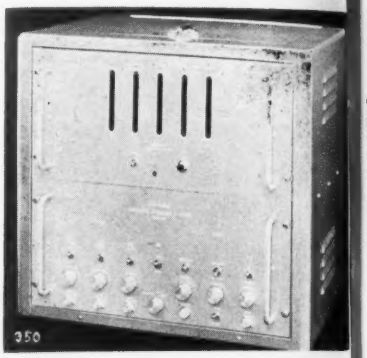
New "Atcotran Amplifier" is a high-gain Class "A" amplifier specifically designed for driving servomechanisms from extremely small a-c. input potentials. It consists of a low-impedance transformer input to a dual-triode two-

stage voltage amplifier tube which drives a pentode power amplifier tube having one motor winding in its anode circuit. D-c. voltage for amplifier is obtained from a transformer and a full-wave rectifier tube. D-c. filtering components are in a plug-in unit mounted on top of amplifier for ease of replacement. Possibility of stray pickup is minimized. Sensitivity is approx. 5000 motor-driven positions when used with a 53-rpm servomotor and an "Atcotran" transmitter. Output is a combination of d.c. and a.c. Relatively steady-state d.c. component is approx. 0.024 amp. with 5000-ohm resistance load; maximum a.c. power output into a 5000-ohm resistance load is 3 watts.—*Automatic Temperature Control Co., Inc.,* 5200 *Pulaski Ave., Philadelphia 44, Pa.*

Mention No. 720 when filling out card.

Universal Counter and Timer

New "Model 550 Universal Counter and Timer" counts events, indicates intervals, measures frequencies and speeds. Time intervals over a range of 10 microseconds to 1 second can be measured directly with an accuracy of 1 microseconds. Events occurring regularly or with random distribution at rates of 20 to 100,000 per second can be counted. Basic error is 1 event; period of frequencies from zero to 100,000 cps. can be obtained with accuracy of 10 microseconds. By use of photocell attachments, interval between two separate light flashes may be timed, or duration of a light flash or a dark period may be determined with accuracy of 10 microseconds. Direct decimal presentation of results lessens possibility of operator fatigue.—*Berkeley Scientific Corp., 2200 Wright Ave., Richmond, Calif.*



Mention No. 721 when filling out card.

Timer Connector

New Timer Connector is designed to eliminate down-time when changing automatic timers. Changeover can be made without error, in less than five

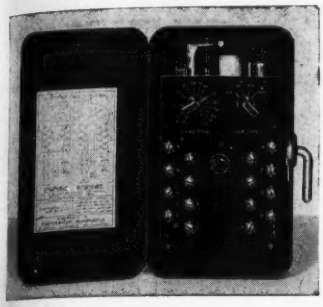
minutes, allowing heat of machine to be maintained; no purging of heater; no wires to tag or remove. Available for all "ATC Series 2800" timers.—*W. C. Bellis,* 15 *Exchange Place, Jersey City, N. J.*

Mention No. 722 when filling out card.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

Burner-program Controller

New "Type 26RJ8 Fireye Programming Control" is designed to provide automatic starting and programming

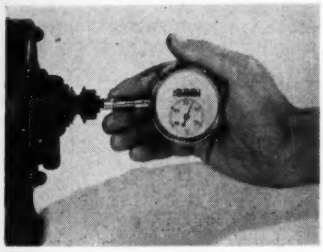


control for commercial and industrial gas, oil, and combination gas/oil burner equipment. It starts a burner in operation and programs a sequence of prepurge, ignition-on, fuel valve delay, post-ignition timing, and post-purge.—*Photoswitch Inc. and Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Mention No. 723 when filling out card.

Tachoscope

New combination stopwatch and revolution counter measures speed of motors, machinery, rotating shafts, etc. When pressed against revolving shaft,

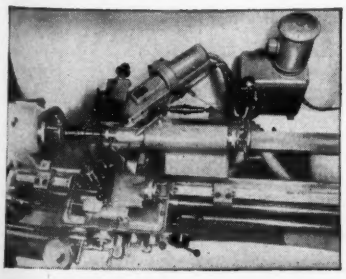


counter and stopwatch are simultaneously engaged and running; operator releases after 30 or 60 seconds and reads revolutions per time interval directly from dial. Turning knob resets counter to zero and also rewinds stopwatch.—*Montgomery and Co., Inc., 53 Park Place, New York 7, N.Y.*

Mention No. 724 when filling out card.

Contour Control for Lathes

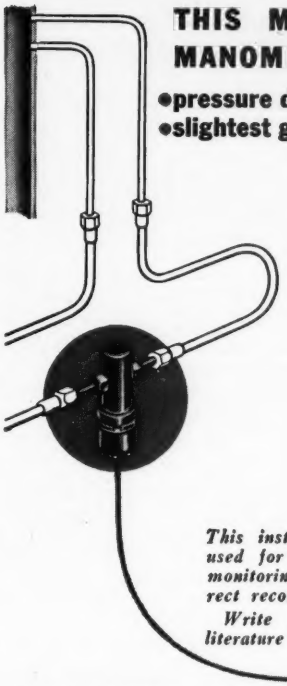
New "Bondycop" (Swiss) hydraulic copying attachment makes it possible to turn almost any lathe into an automatic tracer controlled machine. Mass



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

THIS MICRO-PRESSURE ELECTRONIC MANOMETER-FLOWMETER MEASURES

•pressure differences as small as 1/1,000,000 psi
•slightest gas flow with practically no pressure drop



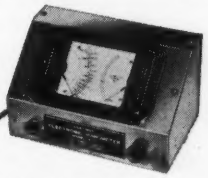
A new type manometer for critical applications and micro pressures. Highly sensitive, stable, yet lower in cost than less accurate instruments. Gauge tube can be mounted in a bypass outside pipe orifice, producing negligible pressure drop.

Compact low-temperature noble metal gauge tube is unaffected by high pressures. Meter sensitivity remains constant, regardless of lead length.

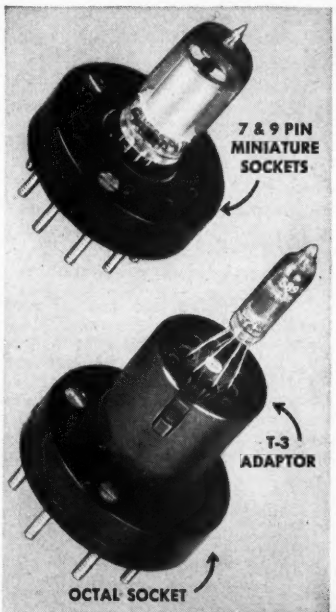
Dual range logarithmic type scales read directly from 0.001″ to 0.1″, and 0.1″ to 2″ water without recalibration between ranges. Response time, less than ½ second.

This instrument can be used for master station monitoring or with a direct recording unit.

Write for descriptive literature and prices.



HASTINGS INSTRUMENT COMPANY, INC.
HAMPTON 35, VIRGINIA
DESIGNERS AND BUILDERS OF RAYDIST AND SPECIAL ELECTRONIC, ELECTRICAL, AND MECHANICAL INSTRUMENTS



RACK UP SUBSTANTIAL SAVINGS

With user-designed test rack sockets

Now you can test subminiature tubes in octal test rack sockets! The Sylvania subminiature tube adaptor plugs into a standard octal socket. This unique test adaptor features a movable locking ring which assures excellent lead-to-contact union.

Sylvania now manufactures a complete line of test rack sockets designed especially for production testing of radio tubes. These sockets are available for 7- and 9-pin miniature tubes and octal tubes. Made of general-purpose phenolic: insulator and contacts are ruggedly constructed to withstand many tube insertions and withdrawals. For complete details write: Sylvania Electric Products Inc., Dept. A-2207, Warren, Pa.

SYLVANIA

RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

production is said to be practical even for small batches because setting usually takes minutes. For a pattern, "Bondycop" uses either first piece of a batch, or a jig, and chance of error is minimized since operator controls only one measurement. Standard size unit can be used for all diameters up to 6 in. and can be supplied in sizes 40 in. to 80 in. between center points. Four essential points: motor, jig holder fixed at rear of lathe, hydraulically controlled tool holder, and control lever. "Bondycop" can be used also for milling.—*Morey Machinery Co., Inc.*, 410 *Broome St., New York* 13, *N. Y.*

Mention No. 725 when filling out card.

Pocket-size Noise Meter

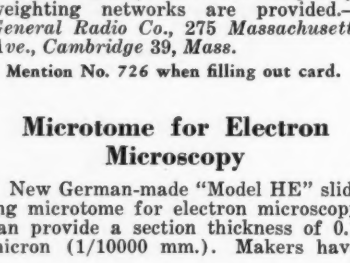
New GR "Type 1555-A Sound-Survey Meter" is smaller, lighter in weight, easier to use, and much lower in cost than standard sound-level meters. Total

sound-pressure-level range is from 40 to 136 decibels, and three frequency-weighting networks are provided.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 726 when filling out card.

Microtome for Electron Microscopy

New German-made "Model HE" sliding microtome for electron microscopy can provide a section thickness of 0.1 micron (1/10000 mm.). Makers have

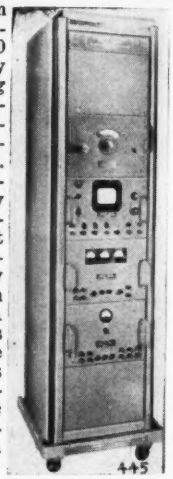


given consideration also to requirements of phase-contrast microscopy. Instrument not only permits adjustment of 0.1 micron, but also, for instance, 0.5, 1.0, 1.5, and 2 microns.—*William J. Hacker & Co., Inc.*, 82 *Beaver St., New York* 5, *N. Y.*

Mention No. 727 when filling out card.

VHF and UHF Direct-reading Spectrum Analyzer

New all-band direct-reading spectrum analyzer covers frequency range from 10 to 21,000 Mc. by means of four tuning units. Features include continuous unidial tuning over entire range with 5-kc. resolution at all frequencies. Frequency can be read to an accurracy of 1 percent and dispersion is independent of frequency and available from 250 kc. to 25 Mc. A frequency marker is provided to measure frequency differences from 0 to 25 Mc.—*Polarad Electronics Corp.*, 100 *Metropolitan Avenue, Brooklyn* 11, *N. Y.*



Mention No. 728 when filling out card.

Micro Buret

New "Gilmont Combination Micro Pipet-Buret" simplifies operation; facilitates filling and cleaning, since titrat-

ing fluid does not come in contact with metal: only glass, ruby and teflon.—*Emil Greiner Co.*, 20-26 *N. Moore St., New York, N. Y.*

Mention No. 729 when filling out card.

Powder Cameras for X-ray Diffraction

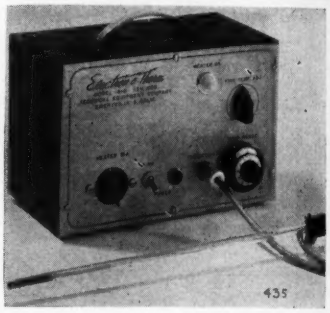
New x-ray diffraction powder cameras are available in two sizes, 114.59 mm. and 57.3 mm. diameters; will record up to 17 Angstrom spacings with copper radiation, with low air scatter and unusually clear patterns in the forward reflection region. Both use 35 mm. film; can be readily adjusted to fit most conventional camera tracks.

Collimators are interchangeable; snap-on light-tight covers are easily removed and replaced. New film mounting device permits use of Straumanis calibration technique or Wilson method whereby film is positioned for calibration without high angle lines.—*Research & Control Instruments Div., North American Philips Co., Inc.*, 750 *S. Fulton Ave., Mount Vernon, N.Y.*

Mention No. 730 when filling out card.

Precision Thermoregulator

New "Electron-o-Therm" is designed for precision temperature control of baths used for refractometers, viscometers, and ASTM equipment; also ovens, furnaces, etc. It consists essentially of a resistance thermometer regulator combined with a precision bridge-

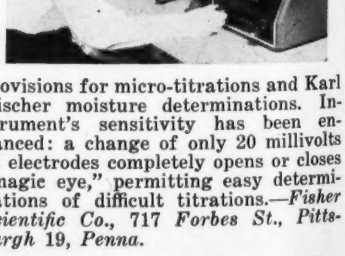


circuit vacuum-tube-amplified controller. Range:—30 C. to 225 C. (others available); regulation limits: 0.001 C.; heater capacity: 1700 watts. Temperature regulator has no moving parts: original precision retained indefinitely. Resistance thermometer is hermetically sealed in Pyrex glass. Heater load circuit is actuated through an enclosed merc-to-merc plunger relay.—*Technical Equipment Co.*, 4348 *San Pablo Ave., Emeryville* 8, *Calif.*

Mention No. 731 when filling out card.

Semi-automatic Titration Apparatus

New model of "Titrimeter," for quantitative determination of solutions, features a completely new stand, improved stirrer and control box, and integral



provisions for micro-titrations and Karl Fischer moisture determinations. Instrument's sensitivity has been enhanced: a change of only 20 millivolts at electrodes completely opens or closes "magic eye," permitting easy determinations of difficult titrations.—*Fisher Scientific Co.*, 717 *Forbes St., Pittsburgh* 19, *Penna.*

Mention No. 732 when filling out card.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

Polarimeter

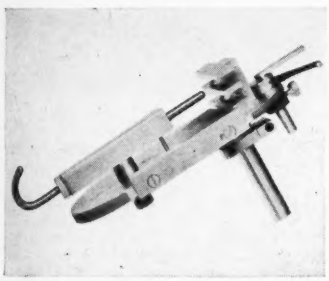
New "Reichert PolM" half-shadow polarimeter (made in Austria) is designed for most exacting requirements in chemical, technical and clinical polar-

imetry. Standard accessories are spare bulb (inside frosted); daylight mirror in mount; orange filter in mount; deep orange filter; observation tube (different types).—*William J. Hacker & Co., Inc., 82 Beaver St., New York City.*

Mention No. 733 when filling out card.

Crystal Orientation Table

New "Type 52190" quartz crystal orientation table, adapted for numerous and varied measurements, has head with multiple x-ray slots to measure

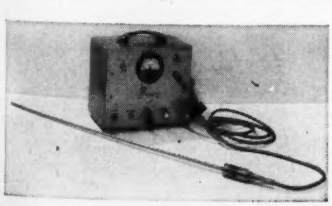


pieces of quartz of varying heights, bar and section holder having a matching height adjustment. Reference guide may be placed on either right or left side of table, which may be used to check angles in mother quartz, sections, bars, wafers, blanks, and test cuts.—*Research & Control Instruments Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.*

Mention No. 734 when filling out card.

Flame-propagation-study Instrumentation

New "Flamometer" detects, amplifies and indicates electrical signals in audio-frequency range, generated by turbulent flames. No significant signal is registered unless probe (ceramic tip supported by a metal rod) is in an actual flame zone which is both ionized and turbulent. Response time is about



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

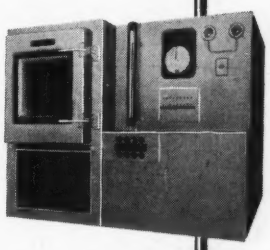
temperatures! atmospheres! pressures!

For ACCURACY TEST WITH Tenney

. . . for Tenney Test Chambers are precision-engineered for maximum efficiency and can be designed to simulate the complete range of temperature, atmospheric or pressure conditions found anywhere on earth—or above it to altitudes of 120,000 ft. plus! They attain sub-zero temperatures quickly, maintain them efficiently and provide full instrumentation for accurate evaluation of complete test data.

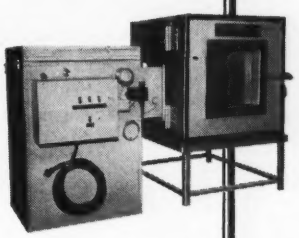
TENNEYZPHERE ALTITUDE CHAMBERS

Designed to withstand atmospheric pressure and to simulate global conditions of pressures, temperatures and humidities. Altitudes from sea level to approx. 80,000 ft. Temperature range from plus 200°F to minus 100°F. Also simulates desired (20% to 95%) relative humidity.



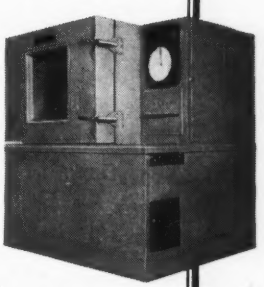
TENNEY SERVO UNIT

Portable air conditioning unit which may easily be attached to various types of laboratory enclosures—impact machines; tension machines; torsion testers; cold boxes and similar equipment. Through its use, articles undergoing testing, aging or weathering can be subjected to wide variations of humidity, heat and cold. Photo shows servo attached to companion chamber.



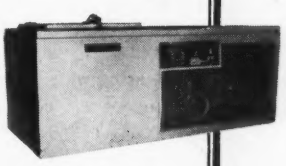
TENNEY TEMPERATURE AND HUMIDITY CHAMBER

Designed for positive control of temperature, humidity and air circulation. Permits the accurate checking of physical quality, fragility, tension and other factors. Also built to incorporate extreme low temperatures, to −100°F.



TENNEY SUB-ARCTIC INDUSTRIAL CABINETS

Designed for low-temperature testing of metals, radios, instruments, plastics, liquids, chemicals and pharmaceuticals. Temperature ranges of −40°F, −60°F, −95°F and −150°F are standard for each size.



For further information on these and other Tenney test equipment, write to Tenney Engineering, Inc., Dept. B, 26 Avenue B Newark 5, New Jersey.

Tenney

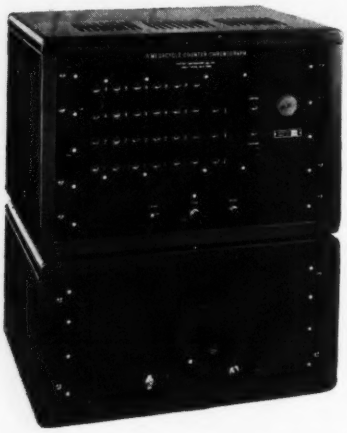
Engineers and Manufacturers of Automatic Environmental Test Equipment

a millisecond. Signal detection is not materially affected by tip temperature. Probe signal is fed to an amplifier with gain control, which allows using instrument on different types of flames. Amplifier output can be: (1) read on instrument panel; (2) used to drive a 0-1 ma. pen recorder; (3) be followed on an oscilloscope; or (4) used to actuate relays or a servomechanism.—*Phillips Petroleum Co., Instruments Div., Bartlesville, Okla.*

Mention No. 735 when filling out card.

Counter Chronograph

New "Model 470" counter chronograph type of intervalometer measures elapsed time in steps of 0.000,000,125 second; incorporates an 8-Mc. crystal



oven for a precise time cycle generator. Results are exhibited on readout lamps in discrete numbers, in whole decimals from a microsecond up, in fractions down to one-eighth microsecond. For intervals longer than one second chronograph will recycle and an external mechanical register may be used to extend count.—*Potter Instrument Co., Inc., 115 Cutter Mill Road, Great Neck, N.Y.*

Mention No. 736 when filling out card.

X-ray Pulse Generators

Three new models, "FX-151," "FX-201" and "FX-301" of portable x-ray pulse generators feature shorter pulse duration, less weight and greater in-

tensity; are designed for radiographic recording of ultraspeed phenomena, particularly in ordnance and ballistics, also in dynamic stress analysis and reaction kinetics. New models differ radically from their predecessor in that each is a single compact unit. Output pulse voltage is continuously variable from 90 kv. to either 150, 200 or 300 kv., depending upon model. All models are designed for 117-vac. 60-cylce operation.—*Microtime Laboratories, 2231 S. Barry Ave., Los Angeles 64, Calif.*

Mention No. 737 when filling out card.

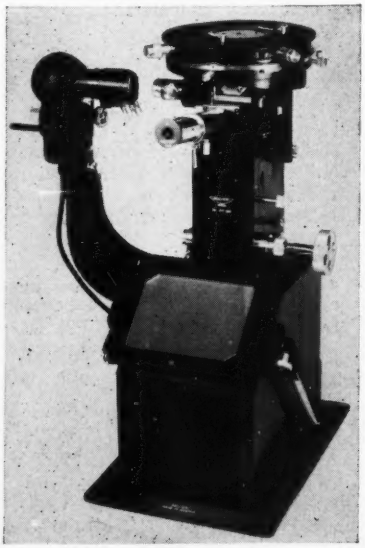
Photoelectric Colorimeter and Turbidimeter

New "Chromatron" photoelectric colorimeter and turbidimeter features selective color filters covering entire visible spectrum, square and round absorption tubes, hermetically-sealed photocell, and automatically focused bulb. It permits analysis of water and sewage by APHA and AWWA standard methods or any other colorimetric procedure. It is exceptionally rugged to withstand rough handling in field or treatment plant.—*Hellige, Inc., 877 Stewart Avenue, Garden City, N. Y.*

Mention No. 738 when filling out card.

Camera Microscope

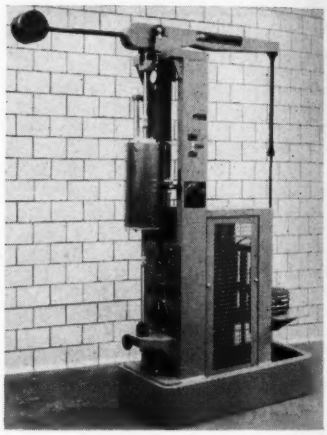
New "Reichert Model MeF Universal Camera Microscope" (made in Austria) is quickly adaptable to all methods of examination. Magnifications, 4.5 to 2200. Observations through eyepiece and on screen are simultaneous. Accessories include micro hardness tester; arc lamp illumination; binocular eyepiece attachment; low-power photomicrography; drawing and projection; photomicrography; phase contrast for transmitted light and for reflected light (in preparation). Attachments are interchangeable and may be ordered as and when needed.—*William J. Hacker & Co., Inc., 82 Beaver St., New York City.*



Mention No. 739 when filling out card.

Creep-Test Apparatus

New "Arcweld" lever-arm creep testing machine of 12,000-lb. capacity (developed by Heppenstall Co. for use in testing its high-temperature alloy steels) has a power-operated lifting mechanism for load weights: platform automatically positions itself about 0.5 inch below weight pan. For testing at temperatures up to 1800 F., exception-



ally large furnace has three heating zones, with temperatures individually regulated from control panel. Furnace is counterbalanced and a position-indicating scale is provided. Furnace windings may be removed in minutes for inspection or repair. Temperature control equipment can be removed as a unit. When used in conjunction with one type of standard controller, "specimen temperature has been held within 1 F. at 1200 F. for long periods."—*Arcweld Mfg. Co., 140 46th St., Pittsburgh 1, Penna.*

Mention No. 740 when filling out card.

Motor and Coil Tester

New "PMD Tester", can detect a single shorted turn of No. 40 AWG wire; is designed to detect faults in and to prevent breakdowns of motors and

generators, coils, etc. Unlike conventional testers which require that windings be energized, PMD test probes generate their own field, oscillating at 800 cps., which accounts for high sensitivity. Rod-like single probes are used to test distributed windings. Field coils and squirrel-cage rotors are tested with dou-

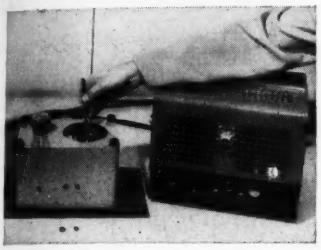
Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

ble probes. Attachments for semi-automatic production line testing are available.—*Columbia Technical Corp., 5 E. 57th St., New York 22, N. Y.*

Mention No. 741 when filling out card.

Torque Tester for Ball Bearings

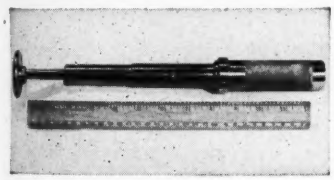
New tester measures torque transmitted through small instrument ball-bearings under thrust loads; is designed for production-line and laboratory work; shows how torque varies as a function of angular position during a continuous slow rotation in either direction; saves many man-hours of assembly and disassembly by detecting dirty or defective bearings before their installation in an instrument.—*General Electric Co., Schenectady 5, N. Y.*



Mention No. 742 when filling out card.

Aircraft Fabric Tester

New portable Impact-Type Fabric Tester (developed by CAA's TDEC) permits tests to be made on airplane without damage to acceptable fabric; is spring-loaded and incorporates a smooth rounded plunger which is driven against fabric surface with a pre-set impact force.—*Steel City Testing Machines, Inc., 8843 Livernois Ave., Detroit 4, Mich.*



Mention No. 743 when filling out card.

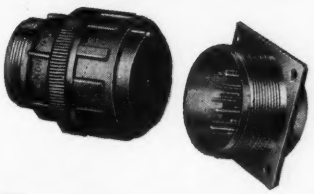
Floor Resistance Tester

New "Vibrotest Model 267" has been developed to measure electrical resistance of conductive flooring in accord-

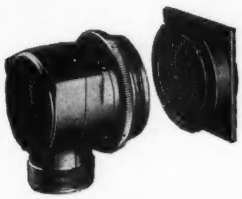
Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

CANNON PLUGS

the highest quality and greatest variety for the instrument industry



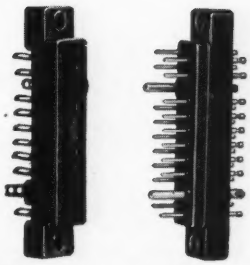
AN Originally designed for Army-Navy Specification requirements. Now used widely for instruments. Connects and disconnects by screw action of threaded coupling ring. Made in 2 plug types—3 receptacles with variations and accessories, in 15 shell sizes and more than 200 insert arrangements.



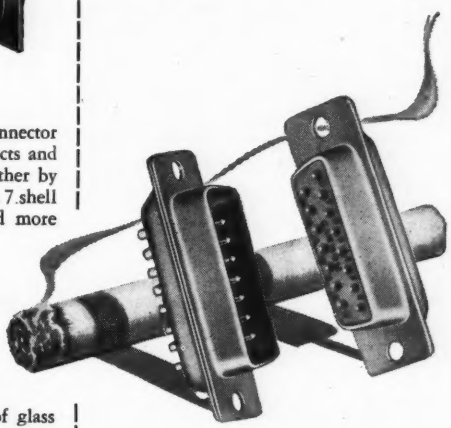
K Light weight, aircraft type connector ideal for many instruments. Connects and disconnects manually. Is held together by Acme thread coupling ring. Made in 7 shell types in 8 different diameters and more than 190 insert arrangements.

GS Hermetically sealed by use of glass fused to shell and contact, both machined from cold rolled steel. Made in 2 shell types —10 diameters and currently having 30 layout arrangements. Additional arrangements are being designed.

RS Hermetically sealed with special resilient rubber inserts. Specially adapted to aircraft relays and other sealed components. These fittings mate with standard "AN" Connectors having corresponding inserts.



DPM This series used primarily on electronic equipment where a multiple contact, rack and panel connector having small dimensions is required. Both plug and receptacle are rigidly mounted. Connect and disconnect automatically when assemblies, to which they are mounted, are joined or separated. Made in 2 sizes having 2 contact arrangements.



D These new sub-miniature Cannon Plugs have 15 contacts for #20 or #22 AWG stranded wire. Others in the series have 25, 37, and 50 contacts. These new plugs meet a long felt need of the Electronics Industry for a sturdy, versatile, and extremely compact connector for use on miniaturized equipment of all kinds. Junction shells make them usable as (1) rack and panel (2) box (3) wall, or (4) cord connectors.

Contacts are machined from copper base alloy, gold plated, rated 5a. High dielectric insulators. Minimum flashover 1000 v.rms. Write for Bulletin D-1.

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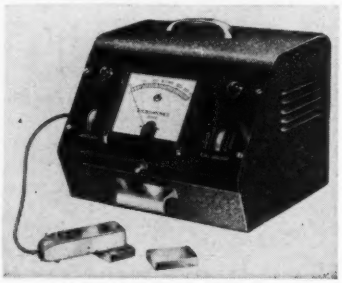
For engineering data on any of these Cannon Plugs request free bulletins by type, such as "K", "GS", "D", etc. Address Department G-180, Cannon Electric Company, P. O. Box 75, Lincoln Heights Station, Los Angeles 31, Calif.

ance with National Fire Protection Association Bulletin 56. Ranges: 0-20 megohms at 125 v.d.c. and 0-200 megohms at 500 v.d.c. test potential; also 0-20,000 ohms and 150-300-600 v. a.c. and d.c.—*Associated Research, Inc.*, 3766 *West Belmont Ave, Chicago* 18, *Ill.*

Mention No. 744 when filling out card.

Surface Comparator

New "Model 100 Surface Comparator" has a roughness range of 1 to 100 microinches rms.; indicates with its needle at an arrested or "frozen"



position: no visual or mental averaging required. Comparator is suitable for any finished surface, flat or curved; is not intended to supplant laboratory instruments but was developed for point-of-production use. Steel cabinet serves as a self-contained carrying case with handle. Weight 17.75 lbs.—*Kota-Meters, Inc.*, 2311 *Burbank St., Dallas* 19, *Texas.*

Mention No. 745 when filling out card.

Static Detector

New "Model 2005 Static Detector" clips onto maker's Vacuum Tube Electrometer, providing a convenient combination for detecting and locating

static charges. Results are observed by noting deflection of electrometer pointer. Sensitivity can be varied over a wide range by raising or lowering inner tube of device. With tube lowered, a charged pocket comb throws pointer off scale from a distance of 10 feet.—*Dep't* 206, *Keithley Instruments*, 3868 *Carnegie Avenue, Cleveland* 15, *Ohio.*

Mention No. 746 when filling out card.

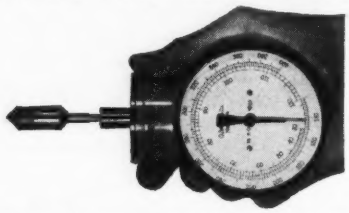
Anti-static Agent

New "Anstac M" anti-static agent is a colorless, easy-to-apply liquid said to make treated product completely static-free. It was developed principally to eliminate dirt and dust attraction on plastic surfaces, can also be used on glass, painted surfaces, etc., where charges accumulate; can be applied by spraying, brushing, dipping, or other conventional methods. Polishing is not necessary.—*Chemical Development Corp., Danvers, Mass.*

Mention No. 747 when filling out card.

Hand Tachometer

New "No. 10 O-Z Single-range Hand Tachometer" is of centrifugal type; has two-scale dial: 30-1200 and 1200-3000 rpm. Pointer makes two turns

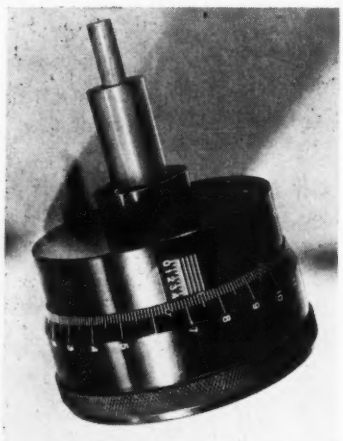


(and its tip travels 32 inches) in going from zero to 3000 rpm. Accuracy is 0.5 percent at any reading—*O. Zernickow Co.*, 15 *Park Row, New York* 7, *N. Y.*

Mention No. 748 when filling out card.

Micrometer Head

New micrometer head, reading directly in tenths and by vernier to 25 millionths, has a spindle which does not rotate as it is advanced or re-



tracted; is suitable for electrical and electronic as well as mechanical applications. Chisel or other special-shaped anvils can easily be provided. Lead-screw's over-all accuracy is 50 millionths in pitch throughout its working range. Compensation is provided by dial mounted scale and vernier, individually set as each instrument is calibrated. Individual setting accuracy is 15 millionths. Instrument is 5 in. long with spindle fully retracted.—*Boeckeler Instrument Co.*, 39 *E. Rillito St., Tucson, Ariz.*

Mention No. 749 when filling out card.

Stylus Pressure Gage

New "Garrard Stylus Pressure Gauge" measures weight exerted by any tone arm; is calibrated with mark-

ings at one-gram intervals. All moving parts are of lightweight alloy and completely sealed.—*Garrard Sales Corp.*, 164 *Duane St., New York* 13, *N. Y.*

Mention No. 750 when filling out card.

Sound Recorder

New console for audio magnetic recording is maker's first to be especially designed for medium-price market.

Among features: all-push-button control, built-in microphone pre-amplifier and full interior accessibility.—*Ampex Electric Corp., Redwood City, Calif.*

Mention No. 751 when filling out card.

Automatic Condensate Pump

New automatic condensate pump has an all-rubber bantam-size centrifugal pump which never requires priming. Non-clogging features permit solids to

pass through without stalling motor. Rating 450 gph. at 2 feet to 168 gph. at 8 feet. Weight, 16 lbs. Automatic control consists of Micro-Switch actuated by copper float inside tank.—*Samuel S. Gelber Co.*, 162 *N. Clinton St., Chicago* 6, *Ill.*

Mention No. 752 when filling out card.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

Tubing Manipulator

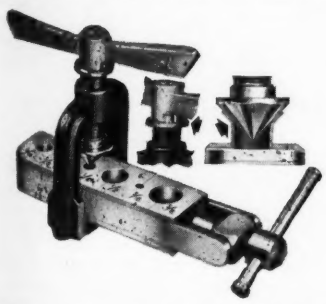
New "Grip-Safe" eliminates hazards of inserting of glass tubes and thermometers in stoppers by providing a gentle but firm gripping action which

permits sliding without excessive or uneven pressure. If tubing breaks, "Grip-Safe" protects hands and wrists. Accommodates most sizes of commonly-used tubing as well as irregular shaped tubing such as T's and L's. May be used also to safely break tubing after marking with file or cutter.—*Labline, Inc., 4710 West North Avenue, Chicago 39, Ill.*

Mention No. 753 when filling out card.

Tubing Flaring Tool

New "No. 500-F Rol-Air" flaring tool for flaring soft copper, steel, aluminum and brass tubing, automatically burnishes face of flare after it has been



formed; will make 45 deg. flares on 3/16, ¼, 5/16, ⅜, ½ and ⅝ in. OD tubing for standard SAE flared fitting joints. Flare forming in air above flaring bar (instead of against a bevel in bar) assures that original wall thickness of tubing is maintained at base of flare.—*The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.*

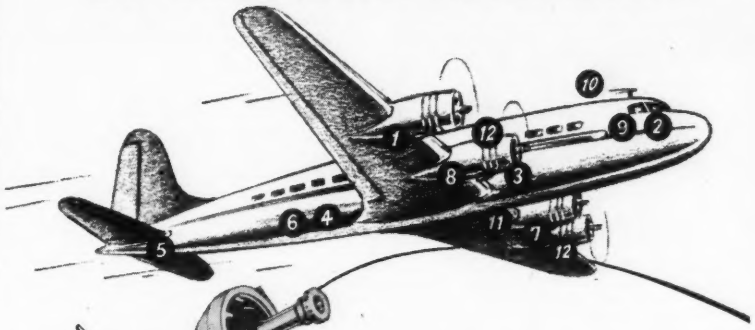
Mention No. 754 when filling out card.

Soldering Tips

New "Elkaloy Tiplets" interchangeable thread-in unit is a trio of individual tips designed to thread into a single heating unit, which in turn, fits maker's handle. "Elkaloy Tiplets" con-

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

IMPROVE AIRCRAFT PERFORMANCE BY USING LORD MOUNTINGS!



Lord Mountings protect the service life of vital aircraft parts and improve the overall operation of aircraft. From engine to empennage, Lord Mountings contribute a full measure of dependability.

Here are but a few examples of Lord Mountings which may help you on present or future designs:

1. **Dynafocal Engine Suspensions**
2. **Instrument Panel Mountings**
3. **Communication Equipment Mountings**
4. **Engine Generator Mountings** (For Flying Boats, for Ground Equip.)
5. **Photographic Equipment Mountings**
6. **Air Conditioning Equipment Mountings**
7. **Cowl Mountings**
8. **Oil Cooler Mountings**
9. **Pilot Seat Mountings**
10. **V. H. F. Antennae Mountings**
11. **Junction Box Mountings**
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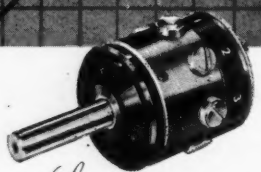
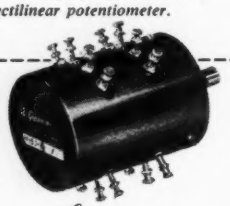


Syncromount

Linear and functional output, rugged construction, ball bearings, small size, low torque, syncro-type mount.

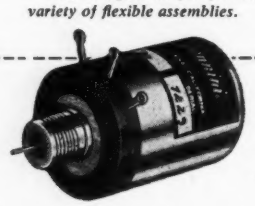
Rectipot

Push-pull motion, linear and functional output, high resolution, rectilinear potentiometer.



Gangpot

Functional and linear outputs, coils independently adjustable, variety of flexible assemblies.



Microtorque

Linear output, minimum torque, potentiometer and selsyn outputs, most ultra sensitive of them all.

These potentiometers are available in a variety of resistance values and circuits. For details on these and other fine instruments, write:

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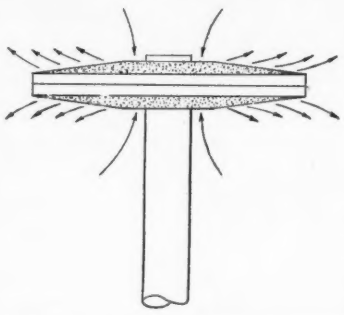
NEW INSTRUMENTS

sist of "No. 535" thread-in heating unit, plus "No. 331 Pencil Tiplet," "No. 332 Offset Tiplet" and "No. 333 Chisel Tiplet." Also announced is new "No. 1235 High-Heat Element" for use in production-line industrial soldering where more heat is required than "No. 535" produces. It, too, is used with "Elkaloy Tiplets."—*Ungar Electric Tools, Inc., Los Angeles 54, California.*

Mention No. 755 when filling out card.

Mixer Filter

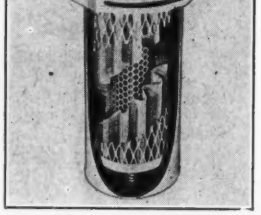
New "Poro Velocel" liquid and gas disperser, mixer and batch filter is a porous stainless steel cell unit mounted on a rotary shaft driven at high velocity. Each half of unit has a saucer-shaped porous stainless steel disk welded to a three-spoke wheel-design stainless steel mounting plate. In operation fluid enters unit through orifices, one above and one below, concentric to rotary shaft. Fluid is thrown out of cell through porous metal walls by centrifugal action, assuring maximum shearing action and optimum dispersion. Standard units are 2⅞ in. O.D; multiple cells can be mounted on shaft for increased capacity. Larger and smaller cells can be furnished.—*Equipoise Controls, Inc. P.O. Box 269, Bronxville, N. Y.*



Mention No. 756 when filling out card.

Water Filters

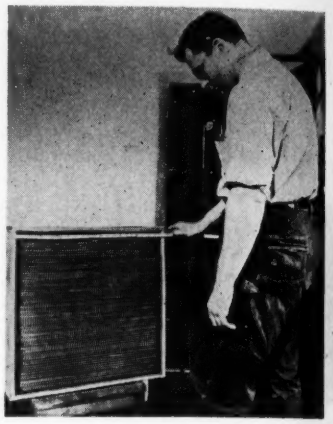
New "Synclinal Filters" are for filtering water. Sump type available in capacities from 5 to 100 gpm.; line type from 5 to 50 gpm. Monel mesh sizes from coarse 30 to fine 200. No changes have been made in basic "balanced synclinal design."—*Marvel Engineering Co., 627 W. Jackson Blvd., Chicago 8, Ill.*



Mention No. 757 when filling out card.

Air Filter

New "Ultra-Aire Space Filter," developed originally to remove radioactive contamination from air exhausted during atomic energy plant operations, is certified to be at least 99.95 percent efficient against particles as small as 0.3 micron. In practice, it removes particules of tobacco smoke (0.05 to 0.1 mircon). It is available in air flow sizes of 50, 500 and 1000 cfm. Effective service life, when protected by a roughing filter, about a year and a half.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Streets, Pittsburgh 8, Penna.*



Mention No. 758 when filling out card.

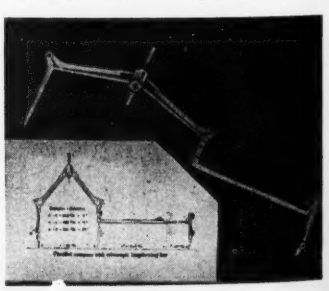
Bore Gage

New "No. 00" dial bore gage, for bores from 0.250 to 0.375 in., is designed to check tolerances up to 0.005 in.; utilizes interchangeable "center-ing-size" disks. Dial indicator is hooded as protection against accidental knocks; has graduations of 0.0001 in. Plunger, is sapphire-tipped and centering-size disks are chromium-plated.—*Standard Gage Co., Poughkeepsie, N. Y.*

Mention No. 759 when filling out card.

Parallel Compass

New "Original Lotter" parallel compass combines advantages of a straight compass, a giant bow and a beam compass (capable of drawing circles up to 26 inches). Feature is parallel opening



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

of lower legs, to whatever extent they are opened. Pen and pencil parts, therefore, always stand perpendicular to drawing paper, with or without self-contained lengthening bars.—*A. Partrick Co., 9 Grove Street, Westwood, N. J.*

Mention No. 760 when filling out card.

Writing Pocket Slide Rule

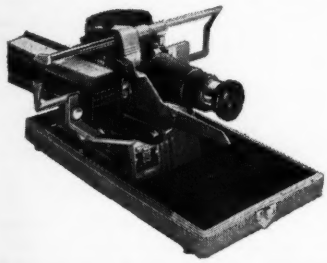
New "Devco" pocket slide rule is incorporated into a two-color quality pencil and magnifier, which also contains an eraser, lead chamber, and a detachable straight-edge. It carries conven-

tional A, B, C, D, L, S, T, as well as extendable CM. and IN. measuring scales. Removable print magnifier, enlarging and plain indicator-cursor and depth gage are embodied in vest-pocket clip.—*Device Development Co., 226 West 4th St., New York 14, N. Y.*

Mention No. 761 when filling out card.

Slide Changer

New "Manual Index 2x2 Slide Changer" fits all maker's "Manumatics" and most other 2x2 projectors; is like maker's automatic but allows operator

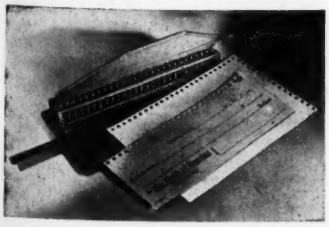


to control all action features manually. It shows 40 slides in sequence, skips, repeats, selects, rejects, and will go backward and forward.—*GoldE Mfg. Co., 1220 W. Madison St., Chicago 7, Ill.*

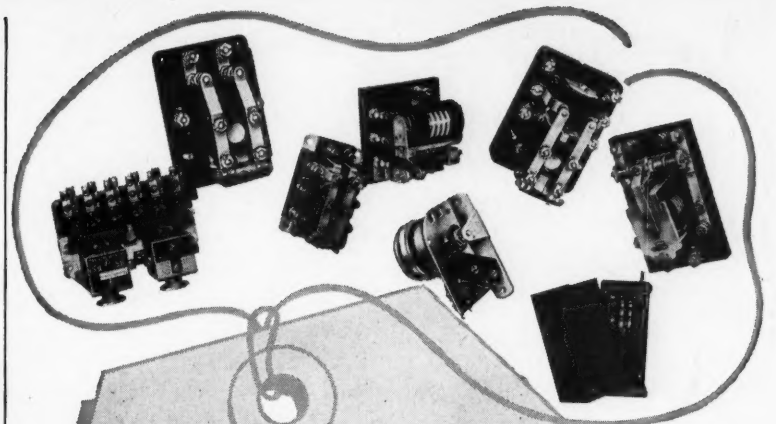
Mention No. 762 when filling out card.

Perforator for Card Coding and Sorting

New "Needlesort Multiple Punch" produces a line of 5/32-inch holes at margin of any file card, office form, or sheet of paper. Cards or sheets so



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX



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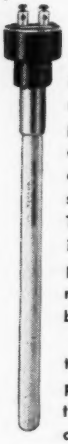

A background of many years of experience and "know-how" go into the production of Gordon Platinum, Platinum-Rhodium Thermocouples. From this experience has evolved the Gordon policy which calls for the utmost in quality and service, the utmost in value to clients. That is why Gordon platinum wire is carefully checked for thermocouple accuracy against a master thermocouple... calibrated and certified by the National Bureau of Standards.

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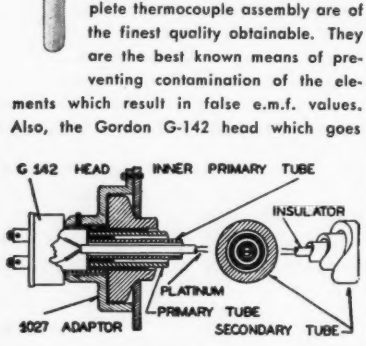

into a complete thermocouple assembly is light in weight and permits easy replacement of new elements into a protecting tube assembly.

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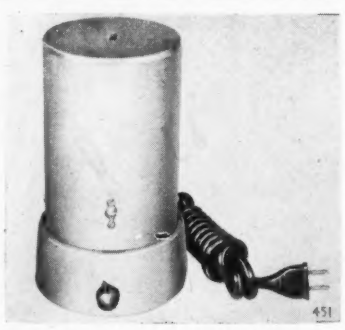
NEW INSTRUMENTS

punched are transformed into equivalent of edge-punched cards as developed by manufacturers of punched-card equipment. Punch produces 27 holes along 8-½" of card edge. An adjustable gage is provided for positioning paper. Cards do not have to be specially printed; may be run through a mimeograph after holes have been produced. A hand punch is available for edge-punching and a selector needle for sorting out wanted cards. No other equipment is required.—*Boeckeler Instrument Co., P. O. Box* 181, *Tucson, Ariz.*

Mention No. 763 when filling out card.

Photograph Marker

New "Foto-Marker," for printing identifying numbers on spectrograms, metallographic plates and photographic



records of all types, operates on 115-volt a.c. or d.c. and power consumption is virtually zero: 6-watt lamp lights only momentarily.—*Millen Manufacturing Div., P. O. Box* 3911, *Detroit* 27, *Mich.*

Mention No. 764 when filling out card.

Radioactive Glycerol

New (in commercial availability) is radioactive glycerol (glycerol-1-C^{14}), which will make it possible to study fat metabolism, pituitary hormones, bile secretion, blood sugar and other growth processes; also industrial processes.—*United States Testing Co., Inc.,* 1415 *Park Avenue, Hoboken, N. J.*

Mention No. 765 when filling out card.

Magnetic-base Holder

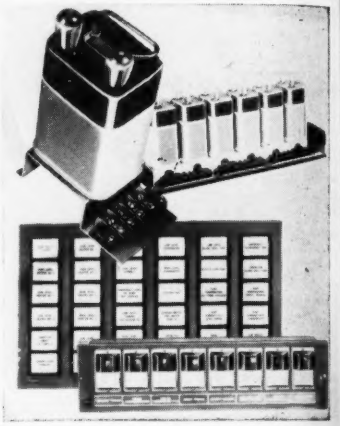
New "No. 120 Miti-Mite" is a portable magnetic base holder for magnifier and dial indicators which attaches instantly with 50-lb. pull to curved or flat surfaces. Outfit includes 2 in.

double-lens 4-power non-distortion magnifier and complete accessories for taking most small dial indicators.—*Ence Mfg. Co.,* 4524 *W. Fullerton Ave., Chicago* 39, *Ill.*

Mention No. 766 when filling out card.

Plug-in Alarm Annunciators

New "Tel-Alarm" hermetically-sealed units for remote signalling of failure or other-than-normal operation of valves, pumps, heaters, etc., are of

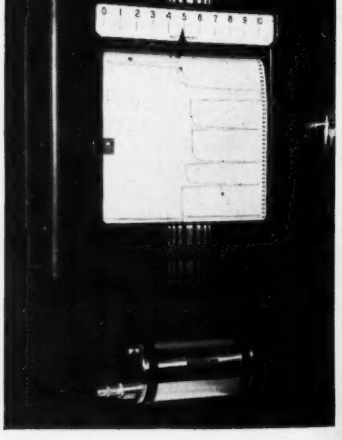


"unitized" construction permitting a great variety of circuit arrangements from one basic alarm unit: a switchboard circuit header is wired into basic relay in different ways depending on circuit desired. Two types of signal lights are available: backlighted nameplates or giant turret lenses for two-light systems.—*Tigerman-Anderson Co.,* 4332 *North Western Ave., Chicago, Ill.*

Mention No. 767 when filling out card.

Gamma-measuring Cell

New "Model RT Cell" converts radioactive energy directly into electrical energy; is designed for precision measurement of gamma radiation; may be used for continuous monitoring of ambient radiation (as in health physics work) or to follow continuous processes



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

where gamma-ray activity is present. Cell has a centrally-located sample well, permitting use for accurate preparation of radioactive dosages for medical services, since nearly 100 percent geometry is obtained. When connected to a recorder, chart record shows (1) number of doses prepared and (2) amount of activity in each dose. When new cell is used with a recording (or indicating) instrument, signal contacts may be included to sound high or low alarms, or pneumatic or electric power units may be employed for automatic control of processes.—*Ohmart Corp.*, 2347 *Ferguson Road, Cincinnati* 38, *Ohio.*

Mention No. 768 when filling out card.

Proportional or Scintillation Counter

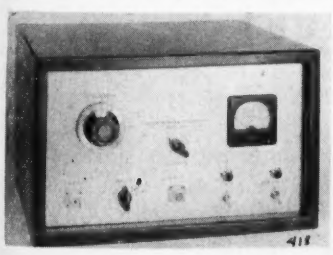
New "DS-1 Candid" decade scale of 1000 is a basic GM tube scaler with space and connections for built-in or remote amplifier-discriminator, optimized for proportional or scintilation counting. Among features: scale of

1000 comprising three identical plug-in decade units; ring-of-five-and-binary circuit to disclose intrinsic scaling errors; resolution time 2 usec.; rapid reset six-digit register totalizes up to 10^7 counts at a rate of 10^6 per minute; built-in timer to 55 min. with error less than 0.2 sec.; 500-1500v (650-2500v optional) regulated power supply; warm-up time delay for GM tube protection.—*Nuclear Measurements Corp.*, 3339 *Central Ave., Indianapolis* 5, *Ind.*

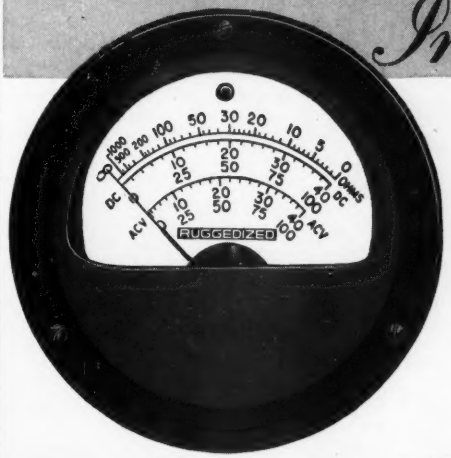
Mention No. 769 when filling out card.

Scintillation Converter

New "Model A-200" scintillation converter unit is designed to allow users to employ scintillation counters with an ordinary Geiger scaler by providing: (1) a high-grain linear response amplifier, (2) a true pulse height discriminator, and (3) a well-regulated and stable high-voltage power supply. Amplifier has a rise time of 0.25 microsec-



Presenting THE NEW DeJUR RUGGEDIZED Instruments

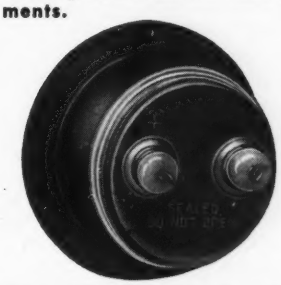


DeJUR Amsco Corporation announces the addition of the new Series R-210 and R-310 Ruggedized Instruments. In meeting government specification MIL-M-10304, DeJUR has incorporated features heretofore unobtainable in ruggedized instruments. They have been designed to meet and even surpass the exhaustive tests required by the armed services. They perform perfectly under the severest service conditions that would destroy conventional instruments.

2½" AND 3½"

RUGGEDIZED D. C. INSTRUMENTS

MODEL R-210 MODEL R-310



MEETS MIL-M-10304

- **Mechanism suspended by internal live rubber ring mounts for maximum shock displacement and protection.**
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- **Glass to metal seal for perfect hermetic sealing.**
- **Drawn steel case with heavy cadmium plate provides high degree of magnetic shielding.**
- **High-grade fusion seals for terminals and window glass withstand thermal shock of extreme temperature changes.**
- **Rugged glass-to-metal seal terminals withstand a 3000 volt breakdown test under extreme humidity conditions.**
- **Entire mechanism has complete ruggedized construction for high shock and vibration resistance.**

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NEW INSTRUMENTS

ond and a variable gain up to 2000, providing sensitivity down to 0.75 mv. pulses. Discriminator is a modified Schmitt trigger circuit adjustable for 0 to −100 volts. Regulating B+ and using it as reference voltage results in less than 0.005 percent change in output voltage for a 1 volt change in input voltage betweeen 95 and 130 volts. —*Nuclear Research & Development, Inc., 1094 Sutter Avenue, St. Louis 5, Mo.*

Mention No. 770 when filling out card.

Radiation Survey Meter

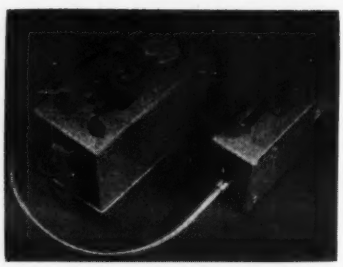
New "Model 2585" wide-range beta-gamma survey meter weighs 3 lbs.; utilizes principle of wartime "Cutie Pie." It can be set upright for con-

tinuous monitoring. Circuit-and-battery housing is ahead of and close to fingers instead of being balanced above handle. The five position switch, provides zero setting and three ranges up to 5000 mr/hr.—*Nuclear Instrument & Chemical Corp., 229 West Erie St., Chicago 10, Ill.*

Mention No. 771 when filling out card.

Radiation Dosimeter

New "Raychronix Model E-1 Fast Neutron Dosimeter" gives a response proportional to human tissue sensitivity over range of 0.2 to 10 Mev. Counter is



of proton recoil proportional type with 2:1 directional response and 10:1 pulse amplitude gamma discrimination. Four ranges: 0-5, 50, 500 mrep/hr; 0-200 integrated total count (approx. equivalent to 0.5 mrep).—*Radioactive Products, Inc., 443 W. Congress, Detroit 26, Mich.*

Mention No. 772 when filling out card.

Gamma-count Tube

New "TGC-8 Small High Efficiency Gamma Geiger Tube," designed especially for medical and other applications where rapid and accurate counting of gamma radiation is essential, provides an end-on efficiency about six

times greater than normal mica end-window tubes, is said to be ideal for counting such gamma emitters as iodine-131. Operating voltage 1100 volts; minimum plateau length 150 volts; plateau slope about 2 percent per 100 volts; useful life greater than 10^8 counts; recovery time about 200 microseconds.—*Tracerlab, Inc., 130 High Street, Boston, Mass.*

Mention No. 773 when filling out card.

Wide-band Voltmeter

New "Model 314 Electronic Voltmeter" measures a-c. voltages from 100 microvolts to 1000 volts in frequency range 15 cps. to 6 Mc.; accuracy is 3

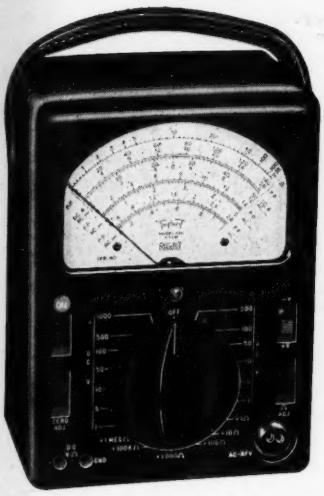
percent up to 3 Mc. and 5 percent above, at all points on single logarithmic scale. With probe, input impedance is 6 mmfd shunted by 11 megs; without probe, input impedance is 25 mmfd shunted by 1.1 megs. Probe has a self-holding connector tip and also a ground clamp designed to insure a low-impedance ground return.—*Ballantine Laboratories, Inc., Boonton, N. J.*

Mention No. 774 when filling out card.

Vacuum-tube Voltmeter

New "Model 650" vacuum-tube voltmeter permits making peak-to-peak ACV and RF measurements with one probe: 20 cps. to well over 110 Mc.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

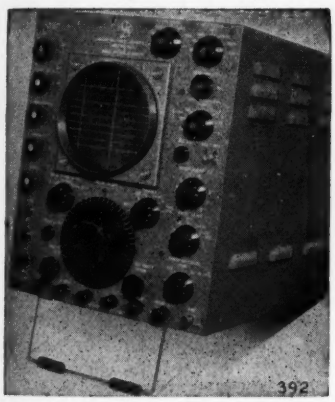


Main selector switch controls all ranges. Tester has one-volt full-scale reading on both a.c. and d.c. Zero center mark for FM discriminator alignment plus any other galvanometer measurements. High input impedance (11 megohms on d.c.) allows for accurate measurements without loading circuit under test.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Mention No. 775 when filling out card.

Oscilloscope

New "Model 401 Oscilloscope" is a high-gain wide-band general-purpose instrument capable of quantitative measurements of high- and low-speed elec-



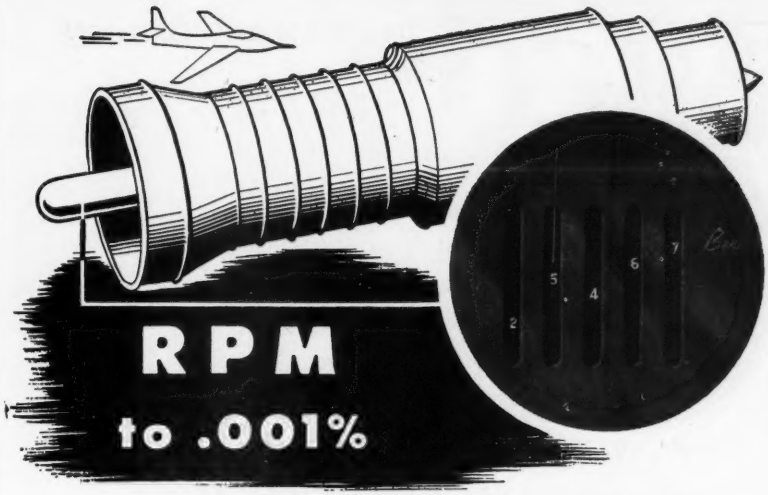
trical phenomena: d.c. to 10 Mc. Y-axis transient response rise time, 0.035 microseconds. X-axis sweep range 0.01 sec/cm. to 0.1 microseconds/cm., delayed sweep range 0-5000 microseconds in three ranges continuously adjustable.—*Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.*

Mention No. 776 when filling out card.

Pulse-rate Generator

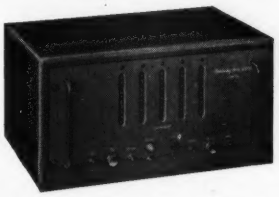
New "Model PG-200" wide-range pulse generator provides internally-generated single pulses and recurrent pulses from 20 to 20,000 cps.; external synchronization 0 to 20 kc. from almost any waveform; direct-reading recurrence rate meter, 20 to 20,000 cps.; pulse duration continuously variable and calibrated from 0.1 to 50 micro-

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX



DIRECT-READING DIGITAL INDICATION OF ROTATIONAL SPEEDS TO .001% ACCURACY

METHOD: Mechanical rotation is transformed into a series of electrical impulses by a magnetic tachometer pick-up. This device consists of a 60 tooth gear mounted on a double-bearing shaft and a magnetic sensing element mounted near the periphery of the gear. Entire assembly is mounted in a small cast housing approximately 7 x 5 x 3 inches. Shaft of ¼" diameter extends 4" beyond outside wall of case.



MECHANICAL COUPLING is made to primary rotating element. As shaft and gear revolve pulse is generated each time a gear tooth passes magnetic sensing element. Thus 60 pulses are generated per revolution of primary rotating element. These pulses are transmitted to EPUT meter which counts for precise 1 second interval and displays result in direct-reading form in terms of RPM. System may be recycled manually or automatically.

VERSATILITY: Under some circumstances, it is not possible to obtain direct access to the primary rotating element. Information must be obtained from a secondary element rotating at some odd ratio with respect to the primary, or from a motor driven generator. Tachometer pick-up devices are available to operate either from direct drive or by synchronous motor drive and to provide whatever conversion factors may be necessary to express the available information in direct-reading form of RPM. Special types of tachometer transducers can be used to measure rotational speeds as high as 100,000 RPM.

MODIFICATIONS: Although the Model 554T electronic tachometer ordinarily operates on the basis of a 1 second sampling period, modification can be supplied to provide 0.1, 0.5, and 10.0 second sampling periods, either individually or selectively. Remote indication can be provided when necessary. The entire equipment can also be supplied in standard explosion-proof housings for industrial installations.

SPECIFICATIONS

RANGE:	300-100,000 rpm.
ACCURACY:	1 event (cycle or fraction of a cycle, depending upon number of pulses generated per revolution) to maximum of .001%.
POWER REQ.	105-130 volts, 50-60 cycles, 175 watts.
DISPLAY TIME:	1-5 seconds variable.
TIME BASE:	1 second standard (see modifications).
DIMENSIONS:	20¾" wide x 10½" high x 15" deep.
PANEL:	19" x 8¾" standard rack panel.
WEIGHT:	Approximately 68 lbs.
PRICE:	$875 plus, depending upon modifications and special requirements.

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These fluxes are unique in that chemical action, so necessary in cleaning metals of oxides, grease, and dirt, does not begin until soldering temperatures are reached. When work cools, any remaining flux subsides into a chemically inert material of low conductivity having non-hygroscopic properties.

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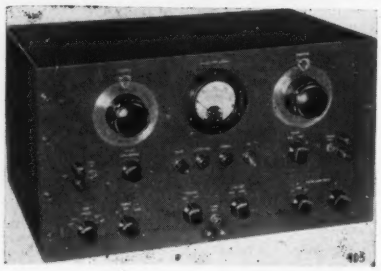
NEW INSTRUMENTS

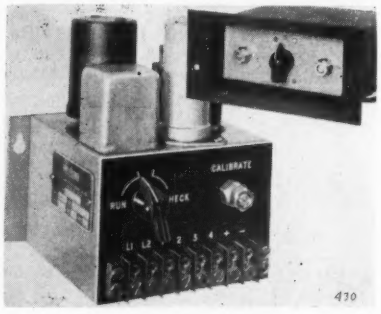


seconds; position continuously variable and calibrated from 50 microseconds advanced to 50 microseconds delayed with respect to synch output trigger; maximum average load current 0.1 amp. automatically limited.—*Dep't I, Telectronics Laboratory, Inc., Kinkel Street, Westbury, L.I., N.Y.*

Mention No. 777 when filling out card.

Instrumentation Demodulators

Three new demodulators are announced for rectifying a-c. signals generated by maker's "Atcotran" transmitters (for pressure, flow, displacement etc.) into d-c. signals that may be fed into millivoltmeters or potentiometers.—*Automatic Temperature Control Co., Inc., 5200 Pulaski Avenue, Phila. 44, Penna.*



Mention No. 778 when filling out card.

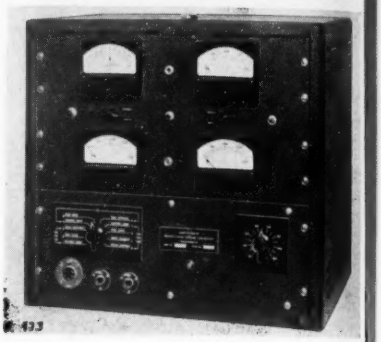
Intermodulation Meter

New "Model IM-35" intermodulation meter is said to feature compactness, simplified operation, high stability, and reduced weight. High-impedance input terminals permit bridging at any point within an amplifier to determine contribution of any stage to total intermodulation factor. Lowest full-scale intermodulation reading is 1 percent and inherent intermodulation of instrument is less than 0.1 percent. Special models for telemetering applications are available.—*D & R, Ltd., 402 E. Gutierrez St., Santa Barbara, Calif.*

Mention No. 779 when filling out card.

Synchro Error Tester

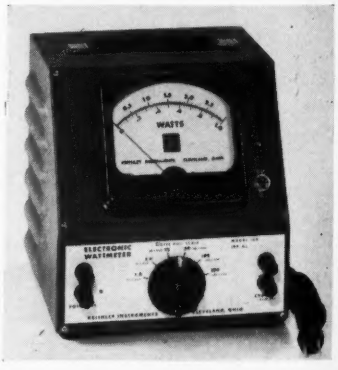
New "Type 226 Synchro Error Tester" makes all electrical tests required by Army Ordnance Specification FXS 1066. With a suitable positioning stand, either 60- or 400-cps. checks are obtained on every 10 deg. of rotation to an accuracy of 10 seconds by turning a selector switch which automatically makes required internal connections to a precision delta network. Tests include coarse and fine electrical zeros, and electrical accuracy of both rotor and stator.—*Pennsylvania Testing Laboratory, Doylestown, Penna.*



Mention No. 780 when filling out card.

Multi-range Wattmeter

New "Model 109 Electronic Wattmeter" employs an amplifier to drive potential coil of a dynamometer wattmeter. Among resultant advantages cited: input impedance of 500,000 ohms eliminating potential-coil current errors; measurement of low-level circuits or those with only a small test potential; frequency response of 20 to 3000 cps. permitting accurate measurement at all power frequencies and their harmonics, of nonlinear circuits with harmonics, and of low audio frequencies. Six ranges, with full-scale values from 1 to 300 watts.—*Keithley Instruments, 3368 Carnegie Avenue, Cleveland 15, Ohio.*



Mention No. 781 when filling out card.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

Volt-amp-wattmeter

New "Model 102 VAW Meter" is an electronic low-power-factor wattmeter covering frequency range of 20 to 20,000 cps. and particularly suitable

for transformer and other magnetic circuit power measurements. Voltage ranges 1.5 to 600 volts and current ranges 0.0015 to 30 amperes give full-scale power ranges of 2.25 milliwatts to 18 kw. at the unity power setting, and 225 microwatts to 1.8 kw. at 10 percent power factor setting. Selection of power factor ranges is accomplished by a single switch rotation. Input impedance 1 megohm; shunt drop 45 millivolts.—*John Fluke Engineering Co., Springdale, Conn.*

Mention No. 782 when filling out card.

Pocket Wheatstone Bridge

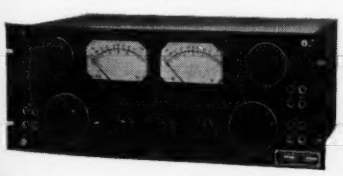
New "Type Z Measuring Bridge" for measuring resistances in the field, workshop or laboratory, can be carried in coat pocket or briefcase. Range is 0.05

to 50,000 ohms over six ratios. Source of supply (flashlight battery) is contained in case. Accuracy is approx. plus or minus one percent.—*Herman H. Sticht Co., 27 Park Place, New York 7, N.Y.*

Mention No. 783 when filling out card.

Transmission Measuring Set

New "Type 10B" transmission measuring set is claimed to provide "far greater accuracy in the measurement of the transmission characteristics of audio systems and their components



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

HIGH SPEED INSTRUMENT Potter COMPANY, INC. ELECTRONIC

COUNTING TIMING CONTROL

INSTRUMENTS

FOR APPLICATIONS INVOLVING THESE BASIC MEASUREMENTS

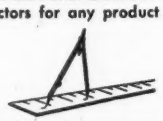
CALCULATION + — ÷ X

For business, industrial and scientific applications requiring computation, data handling, memory and high speed printing, the Potter Instrument Company can supply complete systems. Some of the newly developed equipments include simplified electronic arithmetic units, multipurpose shift registers, storage devices, photoelectric readers, tape handlers and high speed line-at-a-time printer.

QUANTITY

Pills, buttons, bottle caps, hardware, etc., can be counted and batched in precise predetermined quantities at speeds up to 60,000 per minute. Important savings in labor and overages are assured by the speed and accuracy of the Potter Electronic Counter. Count Detectors for any product are available.

LENGTH



Wire or strip material can be automatically sheared or marked in precise predetermined lengths at high rates of speed, and if required, automatically stacked in predetermined quantities. Practically any definition of measurement can be obtained.

TIME

Time intervals can be easily measured or generated with extremely high accuracy through the use of Potter Counter Chronograph Interval Timers. Registration of measurement is retained until reset. Accuracy of one part in 8,000,000 can be provided.

SEQUENCE

Since the electronic counters can be arranged to predetermine any sequence of selected counts, they can be readily and advantageously substituted for cams, gears, patterns, chains and other systems of timing control. Control by absolute count assures high accuracy, faster operating speeds, since there are no moving parts to wear.

FREQUENCY

Potter Electronic Counters provide an exact ratio of division which is maintained even though the input frequency is varied. If the input frequency is stopped the output also stops. Frequencies can be measured or generated with high precision. Square waves of variable frequency, pulse-width and number can be easily generated.

REVOLUTION

Through electromagnetic or photoelectric pickup, shaft rotation can be accurately counted or timed without physical contact. Fractional parts of a revolution can be measured or used to control automatic machine processes as a function of predetermined counts.

PROBLEMS ?

Your specific counting, timing or control problem, explained on our data sheet, will result in a prompt and efficient solution by our engineers.

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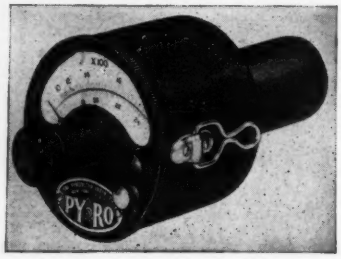
INCORPORATED

117 CUTTER MILL ROAD, GREAT NECK, NEW YORK

The *Only* Instrument You Need to Tell Spot Temperatures *Instantly!*



Just sight it . . . and press the button!

NEW PYRO RADIATION PYROMETER

Any operator can determine spot temperatures in kilns, fire boxes, furnaces, ovens, etc., *accurately—instantly*—with the New **Pyro** Radiation **Pyrometer.** No thermocouples, lead wires or other accessories needed—the **PYRO** is completely self-contained. Just sight it at the object . . . and press the button. Temperature indicated instantly on large direct-reading dial. Two double ranges available 1000/1800—1800/2600° and 1400/2400—2400/3600°F. *Write for FREE Catalog No.* 100.

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NEW INSTRUMENTS

than was ever before available." Circuit consists of a combination of resistive loss and impedance matching networks and shielded isolation coils, so arranged that indicators and their associated range controls can be independently used as VU meters in program monitoring or other applications. Additional feature is provision for feeding noise-distortion meters over a frequency range of 50 to 45,000 cps. from "Load" to "Distrotion-Noise" jacks.—*Daven Company, Dept. G,* 191 *Central Avenue, Newark* 4, *N. J.*

Mention No. 784 when filling out card.

Pulse Transformer

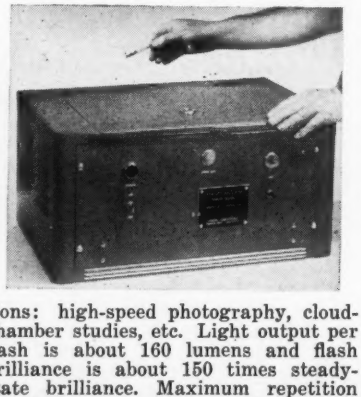
New "Type PT-1" pulse transformer, for use in microsecond and fractional microsecond ranges, is built in an octal tube base. Its windings comprise six

sections: two pairs connected in series, and other two sections individually connected to base pins. Uses: blocking oscillators and other pulse circuits.—*Berkshire Laboratories,* 508 *Beaver Pond Road, Lincoln, Mass.*

Mention No. 785 when filling out card.

Mercury-arc Pulse Supply

New power supply is capable of delivering a 4000-volt 10-microsecond pulse from a 0.5 microfarad capacitor, for use with GE "H-6" or Huggins "Type C" mercury arc lamps. Applica-



tions: high-speed photography, cloud-chamber studies, etc. Light output per flash is about 160 lumens and flash brilliance is about 150 times steady-state brilliance. Maximum repetition rate is one flash per 10 seconds.—*Huggins Laboratories,* 704 *Hamilton Ave., Menlo Park, Calif.*

Mention No. 786 when filling out card.

Dual Power Supply

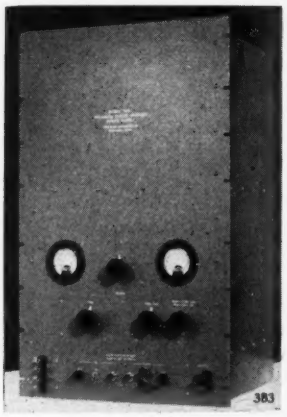
New "Model D4" regulated power supply provides two independent outputs each continuously variable from 0 to 400 v. with 0.5 precent regulation

at loads from 0 to 200 ma. Outputs can be paralleled to double output current or seriesed to double output voltage. Also featured are two continuously variable bias supplies of 0 to −150 volts, d-c. stabilized. Ripple of all outputs is less than 10 mv. Separate meters monitor output voltage and current.—*Oregon Electronic Mfg. Co.,* 2232 *E. Burnside St., Portland* 15, *Ore.*

Mention No. 787 when filling out card.

D-c. Power Supply

New "Model 301A" d-c. power supply has output voltage adjustable from 7.5 to 750 volts at zero to 500 ma. Regulation from zero to full load within 40



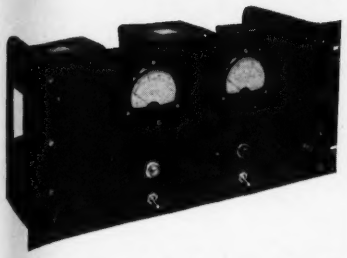
parts per million. Regulation against line voltage changes of 105 to 130 volts 20 ppm. For any output voltage setting, stability is within 100 ppm. per day under usual conditions. Auxiliary negative voltages of 350 and 700 volts d.c. at 0.5 percent regulation at 10 ma. and also 6.3 volts a.c. at 10 amperes.—*John Fluke Engineering Co., Springdale, Conn.*

Mention No. 788 when filling out card.

D-c. Power Supply

New "Model One 300vdc Regulated Power Supply" has conservative load rating of 0-300 ma. Output voltage is manually adjustable over a plus and minus 10 percent range by means of a precision bridge. Abundant filtering and a high-gain ultrastable regulator produce an impedance level below 0.1 ohm, with combined ripple and jitter less than 0.5 mv. To withstand impulse

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

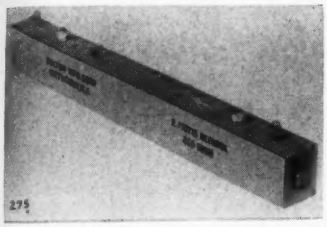


loads, output terminals are directly shunted by a 15-mfd oil capacitor. All transformers and inductors are hermetically sealed and have grain-oriented cores.—*Eastgap Co.*, 285 *Columbus Ave., Boston* 16, *Mass.*

Mention No. 789 when filling out card.

Electrical Delay Lines

New electrical delay lines, for use in computors, radar, TV, etc., where delays are required ranging up to 100

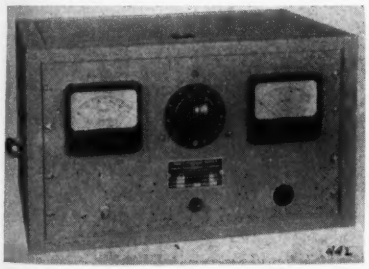


microseconds, feature low-loss, excellent temperature stability through use of temperature compensating capacitors, and small physical size. *Gulton Mfg. Corp.*, 212 *Durham Ave., Metuchen, N. J.*

Mention No. 790 when filling out card.

Regulated Power Supply

New "Model No. MS168B" power supply is rated at 0-30 volts and 15 amperes continuously with a ripple of less than 1 percent and a voltage regu-



lation of 0.5 volt from no load to full load. Unit utilizes selenium rectifiers and a magnetic amplifier circuit for voltage regulation. Cabinet is suitable for either rack panel or bench mounting.—*Perkin Engineering Corp.*, 345 *Kansas St., El Segundo, Calif.*

Mention No. 791 when filling out card.

D-c. Power Supplies

New "Series 400 Precision Direct Current Power Supplies" are designed to meet nucleonic needs. Typical models are "400B" with an output voltage from 1000 to 5000; and "400C" from 500 to 1500. Both are rated 1 ma. and hold output voltages constant to 0.01 percent

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

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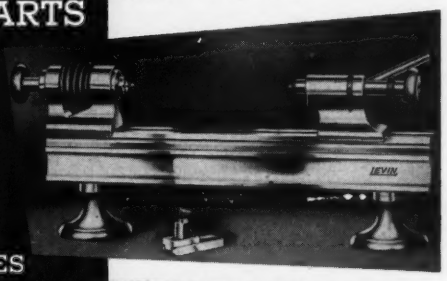

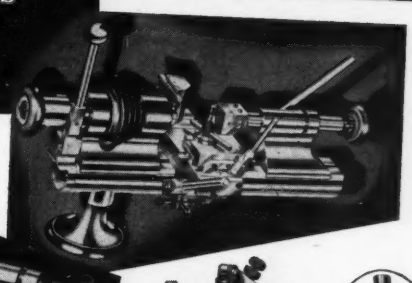

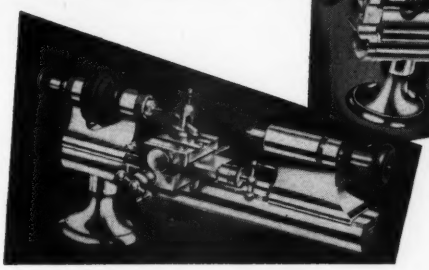

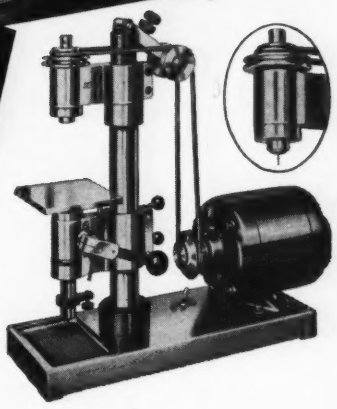

An extremely sensitive drill press for very small drills down to .002". Drills held in accurate collets to minimize deviation. Spindle run-out less than .0001". Finger tip control enables operator to feel progress of drill.

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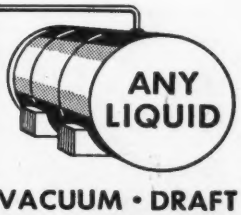
FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY



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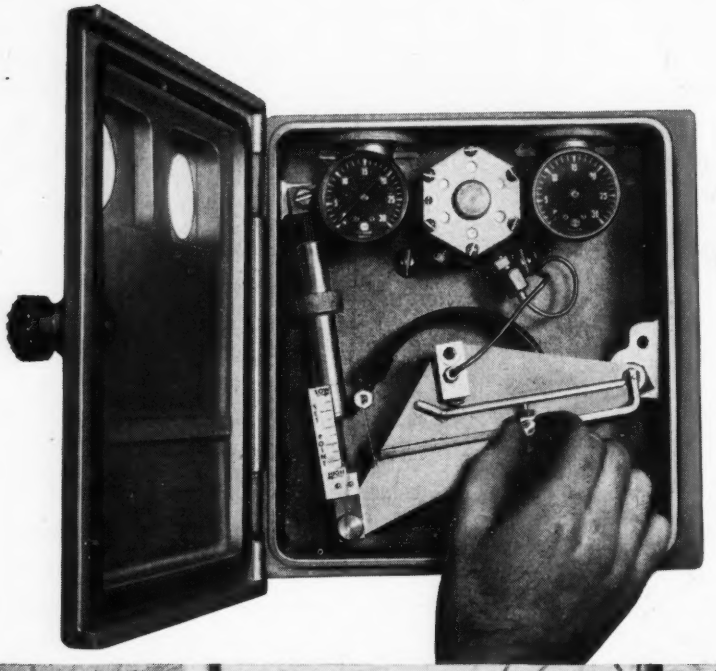
Here's the new

HONEYWELL PRESSURE

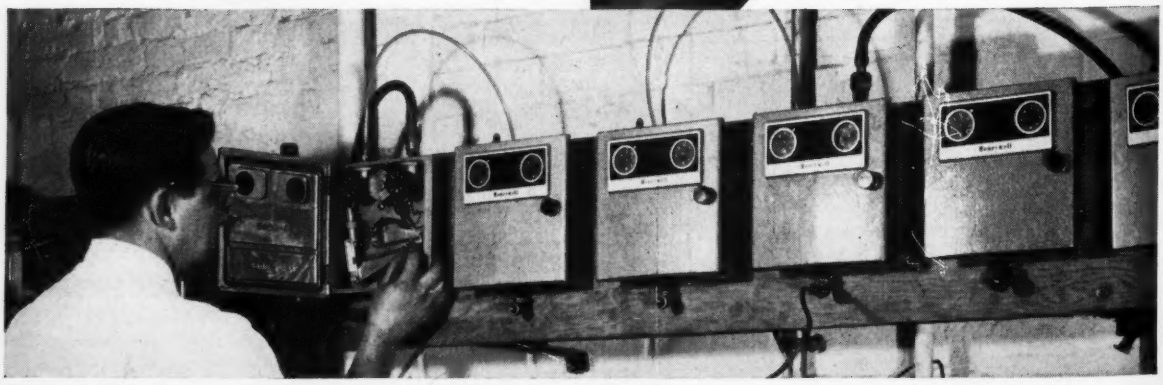
the **heavy-duty** controller

designed for accuracy at low cost

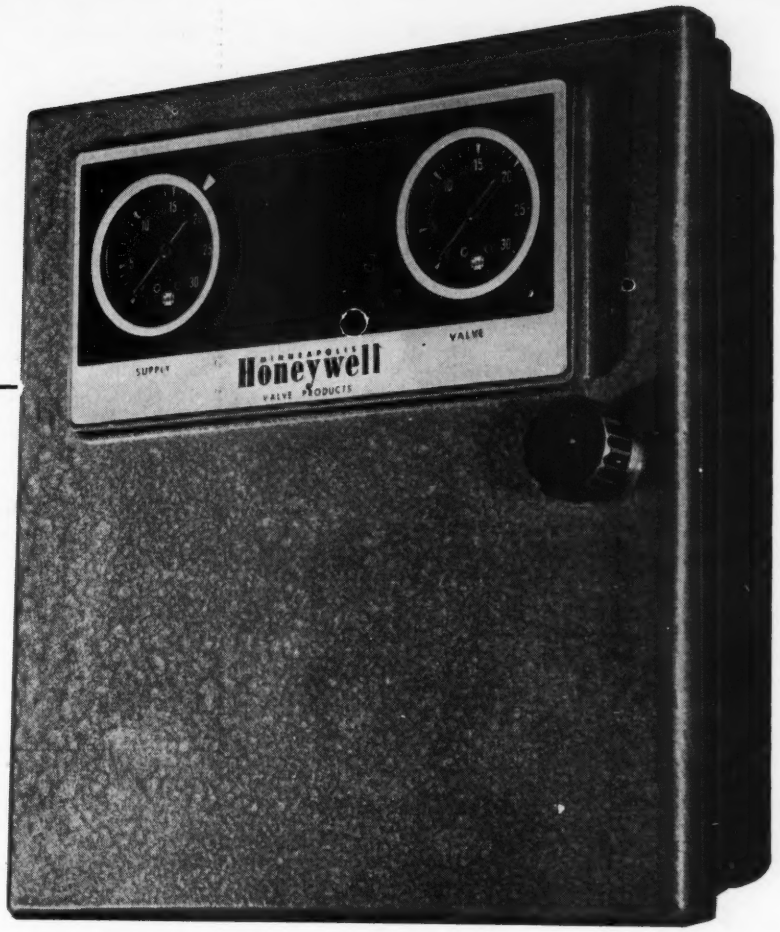


A look inside the Honeywell Pressure Pilot shows its simple design, rugged construction, and accessibility of all adjustments.

Every Pressure Pilot undergoes rigid inspection and testing before shipment.



PILOT



SPECIFICALLY designed for applications requiring accurate control where more expensive indicating or recording instruments are not warranted, the Honeywell Pressure Pilot is ideal for regulating pressure of separators, pump outlets, hydraulic systems, fluid transmission lines, cooling water lines, turbine oil, and furnace fuels.

The Pressure Pilot employs a Bourdon tube to detect line pressure changes . . . a flapper and nozzle assembly to provide a corresponding air signal pressure . . . and a pneumatic relay which amplifies the signal to position a diaphragm control valve.

Exceptional simplicity of design characterizes this new controller. Among its outstanding features are a convenient set point adjustment, unique overpressure safeguard, easy reversibility, and universal mounting.

For accurate control at low cost, for rugged construction, for dependable pressure control . . . your best buy is the Honeywell Pressure Pilot. Our local engineering representative will welcome the opportunity to give you a demonstration in your plant. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 1908 Windrim Ave., Philadelphia 44, Pa.

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Write for new Bulletin 16-1, "Honeywell Pressure Pilot."

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Don't tear down your instruments!

The ENG-SOL Method of Precision Parts cleaning now makes it possible to whisk away fingerprints, oil, grease, dirt, lapping compounds, abrasives, lint, or other contamination.

Our bulletin "Precision Cleaning" describes this new high-velocity compressed air method of cleaning.

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NEW CONSTANT DIFFERENTIAL RELAY TYPE 6000

For purge systems, liquid level and specific gravity measurements.

Maintains constant purge rate regardless of down stream pressure changes • Supplied with fixed flow rate orifice • Eliminates supply pressure regulator • Pressure rating 600 P.S.I. • Supplied with differential indicator • Standard flow rates available .5-1-2-5-25-50 S. C. F. H.

Write for Illustrated Bulletin.

INSTRUMENTS, INC.

122 N. Madison Tulsa 6, Okla.

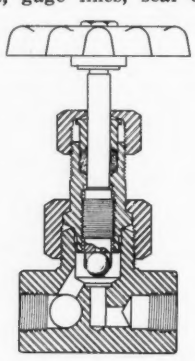
NEW INSTRUMENTS

short term, and to 0.1 percent per day. Noise and hum do not exceed 0.01 percent of lowest output voltage.—*John Fluke Engineering Co., Springdale, Conn.*

Mention No. 792 when filling out card.

3000-psi. Ball Valve

New quarter-inch ball valve, recommended for working pressures up to 3000 psi., is especially useful on meter manifolds, gage lines, seal chambers,



etc. Tight shutoff is provided by a stainless-steel free-rolling ball which closes into a machined conical seat. Long-stroke stem and packing gland are stainless steel; packing is preformed graphited-asbestos with plastic binder and can easily be replaced without shutting off line pressure or interrupting controlled process. Straight-through and angle types are available with two and four connections.—*The Foxboro Co., Foxboro, Mass.*

Mention No. 793 when filling out card.

Diaphragm Valves

New "Quick-As-Wink" diaphragm-operated spring-return single-plunger valves operate on instrument air at 12 to 35 psi. Housing is aluminum. Stainless steel plunger is hollow with precision-placed radial ports. Spring return placing permits open-end exhaust

if desired. Valves can be completely disassembled and reassembled in a few minutes without disturbing main piping; are furnished tapped for either ⅛ or ¼ in. pipe connection, in 2-way; 3-way; double 2-way; 4-way; and 5-way designs for use with air, oil or water at line pressures up to 125 psi.; also vacuum; at temperatures not exceeding 150 F.—*C. B. Hunt & Son, Inc., Salem, Ohio.*

Mention No. 794 when filling out card.

Slurry Flow Control Valve

New "Ratogate" valve, for proportioning and controlling pulp and paper stock and similar slurries, assures a range of operation of 13 to 1 or better,

as it will throttle automatically and remain free from plugging even at flow rates as low as 30 gpm. Diamond-shaped outlet, formed by V-notches of discharge port and sliding gate, provides minimum wetted perimeter and maximum opening area so that stock cannot accumulate to block passage. Valve is self-cleaning: swept clean by agitating action of flow through body; no internal pockets where dead stock can collect. A sight-glass window permits inspection of discharge port and sliding gate. Valves are equipped with air cylinder operators and positioners; in smaller sizes, positioner is part of operator; is externally mounted on larger sizes. Tapped openings permit adding water purge line to flush inner valve in shutdown. Standard material Type 304 stainless steel; others available. Stems and sliding gates polished Type 316 stainless steel.—*Fischer & Porter Co., 6110 County Line Road, Hatboro, Penna.*

Mention No. 795 when filling out card.

Valve and Fitting Cleaner

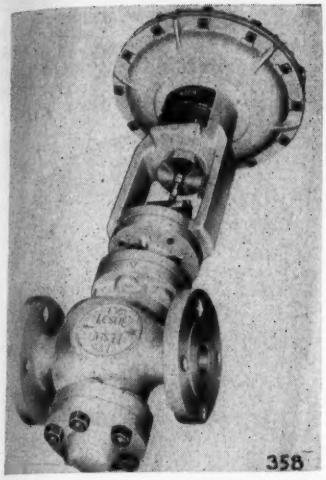
New "Magnus 61RS" is a heavy-duty alkaline cleaner for removing, without unpleasant fumes, all common deposits such as oil, paint, lacquer, carbon, and even heavy coke-like deposits, from valves and fittings to be reconditioned.—*Magnus Chemical Co., South Ave., Garwood, N. J.*

Mention No. 796 when filling out card.

Diaphragm-motor Valve

New "Class DV" double-seated diaphragm-motor valve is said to provide, as standard equipment, features heretofore only obtainable in expensive special valves; is available in sizes from 1.5 in. to 10 in., for pressures to 600 psi., with superstructures from 50 to 210 sq. in., also choice of four trim materials. "Flow-Line" contoured body provides ISA standard face-to-face dimensions with highest capacity, lowest turbulence and body pressure drop. Seat rings are machined so accurately

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

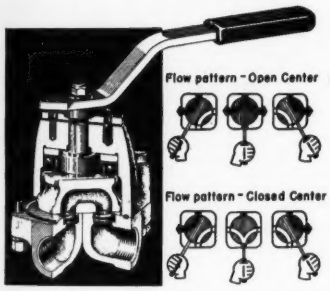


that they can be removed and replaced without removing valve body from pipe line. Also permitting maintenance by inexperienced help are renewable self-aligning top and bottom guides which cannot bind regardless of bolt tightening.—*Leslie Co.*, 225 *Delafield Avenue, Lyndhurst, N. J.*

Mention No. 797 when filling out card.

Hydraulic-system Valve

New "Manipulator" valve for 0-to-3000-psi service utilizes "Shear-Seal" principle: tubular sealing members are so designed that they maintain a balance between line presure and sealing

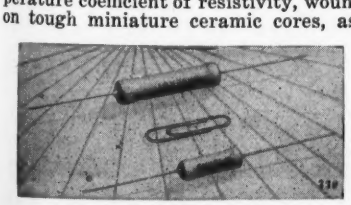


force. Actuation of the valve takes place along the path of least resistance, by shearing stream between two lapped members. New valves come in normally open and normally closed flow patterns from 0.25 in. to 1 in. pipe size, and for manifold mounting.—*Barksdale Valves*, 1566 *East Slauson, Los Angeles* 11, *Calif.*

Mention No. 798 when filling out card.

Miniature Resistors

New "Axiohm" miniature power type resistors with axial leads are made with special alloy resistance wire of low temperature coefficient of resistivity, wound on tough miniature ceramic cores, as-



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

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HIGH VALUE RANGE

10 TO 10,000,000 MEGOHMS

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It gives details of Standard and High Value Resistors, including construction, characteristics, dimensions, etc. Also described are S. S. White 80X Resistors, designed for extremely high voltage equipment. Copy with Price List sent on request.

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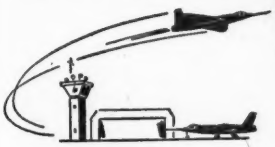

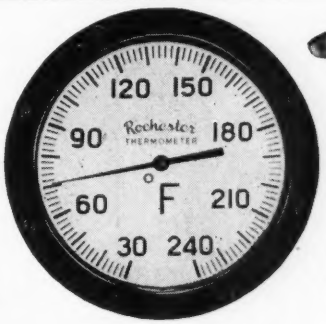

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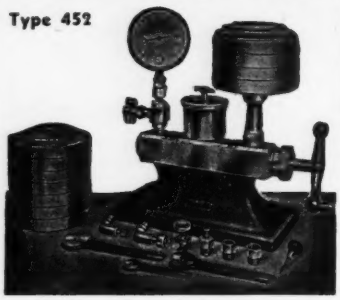

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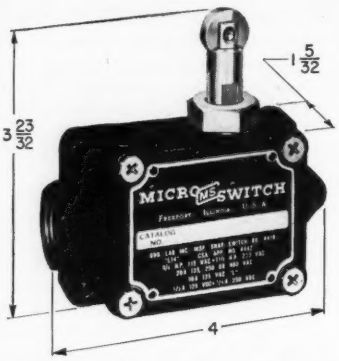
NEW INSTRUMENTS

sembly encased in "Vitrohm" enamel. Available from stock in 5- and 10-watt sizes and wide range of resistance values.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Mention No. 799 when filling out card.

Cam-actuated Switch

New snap-action switch for severe cam actuated service has capacity to make or break steady-state currents of 20 amps. and to handle inrush currents

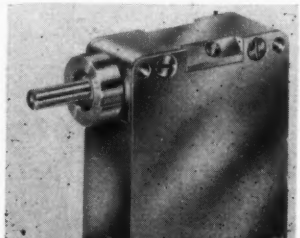


of 75 amps. Plunger assembly can be turned to any position necessary to align roller with direction of cam approach. Operating force, 2.5 lbs., max.; release force, 0.75 lb., min.; pretravel, 3/32 in., max.; differential, 0.010 in., max.; overtravel, 0.187 in., min.—*Micro Switch Div., Freeport, Illinois.*

Mention No. 800 when filling out card.

Aircraft Ice-breaking Immersion-proof Switch

New "Model X-101" aircraft switch has a high-pressure actuating plunger built to break away heavy ice formations in either direction of plunger movement. Terminal block has five terminals with binder head screws so

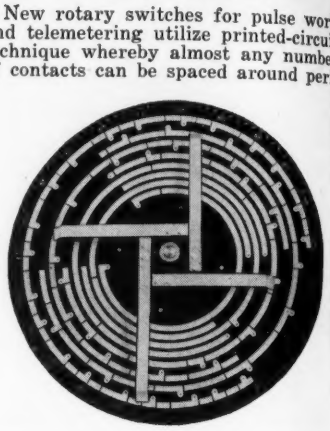


that either single-break (AN-3210-1) or double-break (AN-3216-1) contact arrangements can be handled. Operating force, 22 lb.; force for full overtravel, 35 lb.; release force, 16 lb. Being interchangeable with other aircraft switches, "X-101" is suitable for replacement as well as original installations.—*Unimax Switch Div., The W. L. Maxson Corp., 460 W. 34th St. New York 1, N. Y.*

Mention No. 801 when filling out card.

Rotary Switches

New rotary switches for pulse work and telemetering utilize printed-circuit technique whereby almost any number of contacts can be spaced around peri-

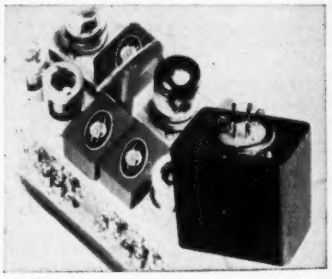


phery of a contact panel at irregular intervals depending on timing required. Either shorting or non-shorting switch action can be obtained. Life expectancy is said to exceed 1,000,000 revolutions.—*Daven Co., 191 Central Ave., Newark 4, N. J.*

Mention No. 802 when filling out card.

Pulse Transformer

New "Type 130 A1" multi-purpose miniature pulse transformer is for use in low-power applications. Three isolated windings provide versatility of

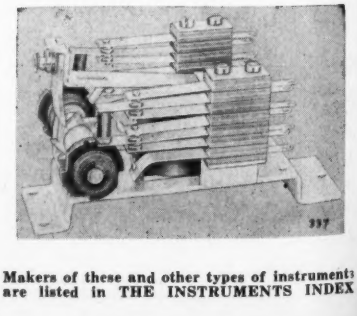


application; through-panel mounting utilizes same mounting hole pattern as nine-pin miniature tube socket; short rise time and small droop minimize critical associated circuit design problems.—*Engineering Research Associates, Inc., Dep't A, 1902 W. Minnehaha Ave., St. Paul 4, Minn.*

Mention No. 803 when filling out card.

Ratchet-type Relay

New "AP Impulse (ratchet-type) Relay" has an automatic stop which prevents slippage or overtravel of ratchet, insuring positive action on each impulse, at high-speed operation



Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

with a contact transfer time as short as 20 milliseconds. Relays are available up to 230 volts a.c. or d.c., contact combinations up to 4-p.d-t. Contacts are 0.375-in. fine silver, rated at 5 amperes, 115-v. a-c. non-inductive load. Balanced armature construction permits mounting in any position.—*Potter & Brumfield, Princeton, Indiana.*

Mention No. 804 when filling out card.

Hermetically-sealed Relay

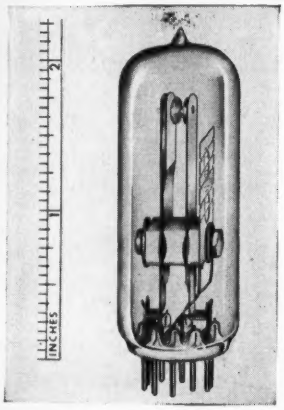
New "CR 2791G" general-purpose hermetically-sealed relay, for use in aircraft, shipboard, and portable land-based electrical systems, is designed to meet or better MIL-R-6106; also con-

forms with AN-3304; is claimed to give from two to six times longer life than existing equipments. It is a 4-p.d-t. relay with a contact rating of 3 amperes, 28 volts d.c. or 115 volts a.c. It will withstand instantaneous voltage surges up to 1500 volts.—*General Electric Co., Schenectady 5, N. Y.*

Mention No. 805 when filling out card.

Miniature Delay Relays

New delay relays are available in T6-½ bulb-base 9-pin miniature; can be supplied for all standard heater voltages. Delays available from 2 to 90



seconds. Wattage consumed by heater is approx. 2 watts. Contact rating: 115 v. 2-amp. a-c. non-inductive.—*Amperite Company, Inc., 561 Broadway, New York 12, N. Y.*

Mention No. 806 when filling out card.

Record/Reproduce Heads

New "BK-1500A series" multi-channel magnetic record/reproduce heads are supplied in cartridge form less housing; available from 1 to 14 channels, channel width 0.050 in.; center-to-center channel spacing 0.125 in.; gap width 0.0005 in. "BK-1500N" series

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

HIGH PRECISION Thermistors from a high precision source

made to your order for
resistance values • size
temperature coefficient • mountings • quality

Widely useful as temperature measuring elements and as liquid level sensors, these temperature responsive resistors are built by Bendix-Friez under a system of quality controls set up to meet exacting military standards of accuracy. You can count on them as the very best obtainable, whether purchased from stock or made to your own specification. Ask for a list of applications.

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Typical application in capsule form for temperature sensing of hydraulic oil.

Size (inches)	@ +30°C.	@0°C.	@ −30°C.
.140 x ¾	45 ohms	88 ohms	193 ohms
.040 x 1.5	14,000 ohms	29,946 ohms	74,676 ohms
.018 x 1.5	40,000 ohms	94,040 ohms	262,400 ohms

Write for details to Dept. F

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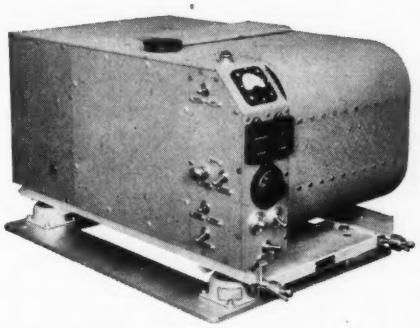
RECORDING OSCILLOGRAPH
FOR VIBRATION, TEMPERATURE, STRESS, STRAIN ANALYSIS



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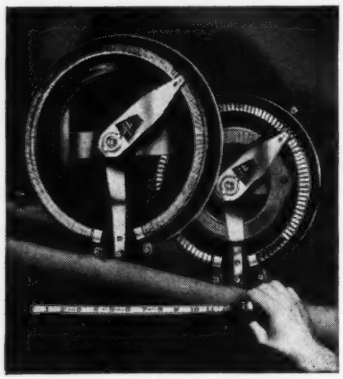
NEW INSTRUMENTS

may be supplied in cartridge from or in housing. Channel width reduced to 0.044 in. so that two multichannel units may be mounted in staggered fashion with interlacing channels.—*Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

Mention No. 807 when filling out card.

Wire-wound Rheostats

New wire-wound vitreous-enameled rheostat models, formerly made-to-order, are now being carried in stock: "Model G," 75 watt; "Model P," 225

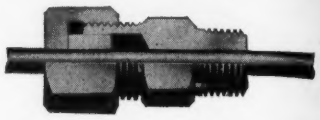


watt; "Model T," 750 watt; and "Model U," 1000 watt; resistance values 0.5 to 10,000 ohms for Model G, and 1 to 2500 ohms for Models P, T, and U.—*Ohmite Mfg. Co., Chicago, Ill.*

Mention No. 808 when filling out card.

Packing Glands

New series of stainless-steel packing glands for process-control, pilot-plant or laboratory installations, are available to accommodate tubes from ⅛ to



13/32 in. (⅛-in. IPS) OD. "PG-2" and "PG-4" are furnished with asbestos-graphite packing for sealing static lines, thermocouple wells, dial thermometer stems, etc. "PG-3" employs powdered talc as a sealant, is chemically inert, may be used at temperatures exceeding 1400 F. but cannot be used as stuffing boxes for moving parts. Inside diameters are bored to customers' specifications.—*Conax Corp., 4515 Main Street, Buffalo 21, N. Y.*

Mention No. 809 when filling out card.

Medium-capacity Rectifiers

New "Style F" medium-capacity rectifier is housed in a 17 x 9 x 9.5 in. cabinet, is available in two sizes with d-c. outputs of: (1) 115 v., 10 amp., (2) 230 v., 6 amp.; both using 220 v. a-c. input.—*Electronic Rectifier Co., Inc., Rochester 2, N. Y.*

Mention No. 810 when filling out card.

Vehicular Bypass Capacitors

New "Type 131J" hermetically-sealed corrosion-resistant capacitors for radio-interference suppression on low-voltage electrical systems of military vehicles

INSTRUMENT EVENTS CALENDAR

July 28-Aug. 1
Gordon Research Conference on Instrumentation sponsored by the American Association for the Advancement of Science, Colby Junior College, New London, N. H. For information write W. George Parks, Director, Dep't of Chemistry, University of Rhode Island, Kingston, R. I.

Sept. 4-13
International Society of Photogrammetry, Shoreham Hotel, Washington D. C. For information write L. Ray Smart, U. S. Geological Survey, Trimetrogon Section, Washington 25, D. C.

Sept. 8-12
Instrument Society of America.
Seventh National Instrument Conference and Exhibit.
Public Auditorium, Cleveland, Ohio.

Sept. 8-19
Special course in Aerodynamic Measurements to be held at the MIT Gas Turbine Lab. For information write Dr. Ernest H. Huntress, Dir. of Summer Session, Room 3-107, Massachusetts Institute of Technology, Cambridge 39, Mass.

Sept. 22-30
Third Instruments and Measurements Conference and Exhibition, Stockholm, Sweden. For information write Mr. Yngve Axner, Kungl. Tekniska Hogspolan, Stockholm 70.

Sept. 29-Oct. 1
Eighth National Electronics Conference and Exhibition.
Sherman Hotel, Chicago.
For information write Karl Kramer, Ex. Sec., 852 E. 83rd St., Chicago 19.

October
Scientific Apparatus Makers Association.
Midyear Meeting of Recorder-Controller Section.
Seaview Country Club, Absecon, N. J.

Nov. 5-9
Scientific Apparatus Makers Association.
Midyear Meeting of Industrial Instrument, Laboratory Apparatus, Laboratory Equipment, Optical, Aeronautical, and Military Instruments Sections. The Homestead, Hot Springs, Va.

Nov. 6-7
Tenth Annual Pittsburgh Diffraction Conference, Mellon Institute of Industrial Research, Pittsburgh, Pa. For information write E. E. Wicker, c/o U. S. Steel Co., 234 Atwood St., Pittsburgh 13, Penna.

Nov. 17-18
AIEE Technical Conference on Electrically-operated Recording and Controlling Instruments. Benjamin Franklin Hotel, Philadelphia, Pa. For information write G. L. Broomell, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44.

Nov. 20-21
Seventh Midwest Conference, American Society for Quality Control, Claypool Hotel, Indianapolis, Ind. For information write Dale A. Cue, Vice-chairman, 7th Mid-West Conference, 5565 Brookville Road, Indianapolis, Ind.

Nov. 20-22
Instrument Maintenance Short Course sponsored by the Los Angeles Harbor Junior College and the Southern California Meter Association at Long Beach, Calif.

Dec. 3-4
Annual Meeting and Exhibits, Society for Experimental Stress Analysis, Hotel McAlpine, New York City. For information write W. M. Murray, Sec.-Treas., P.O. Box 168, Cambridge 39, Mass.

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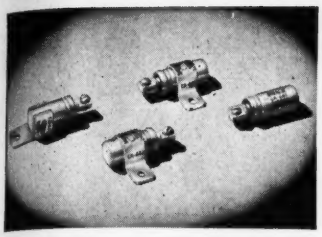


and portable gasoline-driven power plants, meet Army Spec. 71-1667 and Ordnance Drawing DQBX1. Capacitance values: 0.01, 0.1, 1.25, and 0.5 mf.—*Sprague Electric Co.*, 199 *Marshall St., North Adams, Mass.*

Mention No. 811 when filling out card.

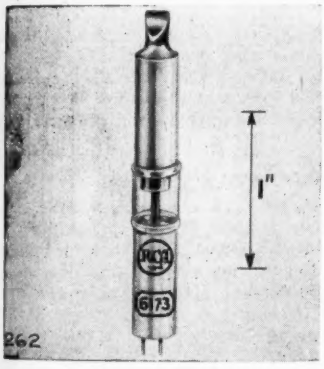
Toroidal Windings

New toroidal coils, characterized by improved winding techniques, meet high "Q" inductor requirements of miniaturized apparatus; utilize powdered-iron or continuous strip-wound core materials, depending upon application. Available in cased or uncased coils, magnetic amplifiers or complete networks.—*D & R, Ltd.*, 402 *E. Gutierrez Street, Santa Barbara, Calif.*

Mention No. 812 when filling out card.

UHF "Pencil-type" Diode

New "6173" high-perveance "pencil-type" diode, designed for pulse-detection and pulse-power-measuring service at frequencies up to 3300 Mc., features



a coaxial electrode structure of double-ended metal-glass type having minimum transit time, low lead inductance, low plate-to-cathode capacitance, and high resonant frequency. Weight, 0.2 oz.—*Tube Dep't, Radio Corp. of America, Harrison, N. J.*

Mention No. 813 when filling out card.

Fluxless Solder and Welding Rod

New "Chemalloy," for use with any aluminum or zinc base metal or alloy, permits either soldering or brazing without fusion, or welding with fusion utilizing capillary attraction; requires no flux, cleaning or physical preparation of metal to be joined or repaired; also permits soft soldering to aluminum when latter is tinned with this new material.—*Chemalloy Associates, Gillespie Airport, Santee, Calif.*

Mention No. 814 when filling out card.

Makers of these and other types of instruments are listed in THE INSTRUMENTS INDEX

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In less than six months, the first printing of our "COMPILATION OF ANALOG TRANSDUCERS" has been nearly exhausted. The Second Edition is now in preparation.

In the First Edition, some 500 transducers of well over a hundred manufacturers were listed, together with their more important characteristics. It is our plan to expand this publication by the inclusion of as much new material as possible.

Thus we invite manufacturers of analog transducers, whose products are not currently listed, to submit for consideration descriptions and specifications of these devices.

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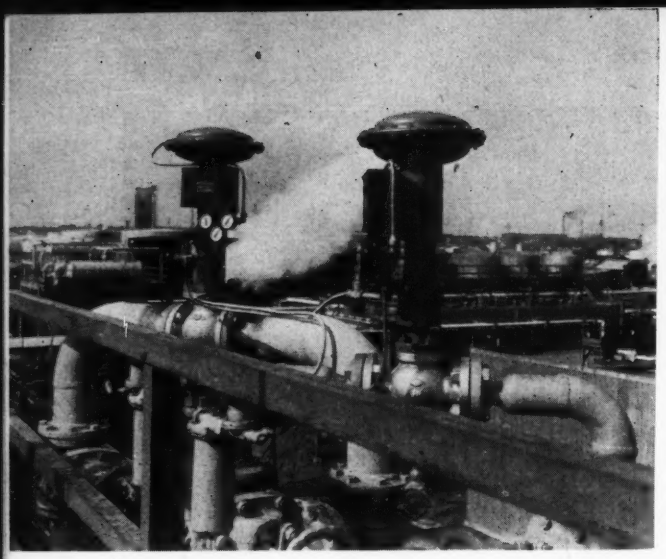


Selecting and Sizing CONTROL VALVES

By OTTO KNEISEL
Hammel-Dahl Company

Selection of the proper control valve for a throttling application can involve consideration of the following 51 itemized factors.

A THROTTLING control valve should be selected with consideration of the system in which it is to operate. There is a wide variety of commercially available equipment. In order to make use of this availability, the performance requirements must be well understood. It is necessary to determine and to consider the following:

(A) The physical properties of the fluid to be controlled. (B) The function of the valve in the process cycle from start-up through normal operation to shut-down; also emergency operation. (C) The piping standards, safety standards, and other regulations or codes concerning the area in which the valve is to be installed. (D) The flow diagram of the process to be controlled; indicate the pressure at the principal stages at the maximum and minimum flow rates. (E) Size the valve and compute the required rangeability of the valve and the estimated rangeability of the system. (F) If the valve is 1 inch or larger, compute the leakage for a double-seated valve at ½ of 1 percent of the valve capacity; if this is excessive, consider the use of a single-seated valve. (G) Additional features required by the specific installation.

Each of these points are now considered in detail.

A. Physical Properties of Fluid to be Controlled

1. *Name and nature of the fluid.* In practice, this is not always readily available information because in the intermediate stages in the process the fluid in a valve is not the same as the end product.

For a liquid, it is necessary to know:

2. The *specific gravity* at standard conditions.

3. The specific gravity at the operating temperature. If the specific gravity at operating temperature is considerably different from the specific gravity at standard conditions, inquire into any possible flashing of the liquid.

4. The *viscosity* at operating temperature. If the fluid is more viscous than medium oil, determine the Reynolds Number in the piping system and also for the valve, when it is sized later on. The network chart "Liquid Flow Reynolds Number" (Fig. 1) is a chart for rapid determination of Reynolds Number from flow rate, nominal size, viscosity, and specific gravity. It is general practice to use a valve for viscous flow one size larger than for non-viscous flow. Except for special viscosity phenomena, this rule of thumb has been found quite satisfactory.

5. *Nature of entrained solids.* The size of solids does not affect the valve sizing but must be considered in the effect on the internal moving parts in the valve. Will the solids pass through the valve? Will they wedge in the inner moving parts? Will the solids build up deposits in the valve guide sections? Sometimes the solid deposits can be removed by flushing with clean fluid.

6. *Flashing condition for the liquid.* The liquid vaporizes, or flashes, in a line or valve if the pressure is less than the vapor pressure. It is necessary to compute the amount of flashing in order to determine the desirable valve size. A method of computing the valve size required for a flashing condition is given in the "Hammel-Dahl Engineering Data Bulletin No. 200" on page 19. The downstream line size should be adequate. The vapor velocity should be no more than 5000 to 10,000 feet per minute. The velocity may be determined on the network chart "Gas or Steam Mean Velocity" (Fig. 2).

7. *pH of the liquid.* This factor is not very well understood in most installations and corrosion failures have occurred in installations due to the pH of the liquid. For instance, boiler feed-water, which is very pure water, can have a pH factor such that carbon-steel parts corrode rapidly.

For steam service, it is necessary to know:

8. *Degrees of super heat,* or percentage saturation of the steam. It is necessary to know the steam temperature in the choice of valve-stem packing. The steam condition must be considered in the valve sizing. If the percentage saturation is less than 90 percent, slugs of water can wear the valve trim rapidly. It then is necessary to use Stellite facing on the valve plug and seat.

For gas service, it is necessary to know:

9. The *specific gravity* at 60 F. and 14.7 psia., or the molecular weight. This information is required for sizing the valve. Sometimes the specific weight or volume at operating conditions is given. The value must be converted to standard temperature and pressure in most sizing methods.

10. The *compressibility* of the gas. In general, it is not necessary to consider the compressibility factor in a gas, unless the pressure drop is more than 1000 psi. The quantity flowing must be determined, considering the compressibility of the gas. There are charts available for determining the compressibility.

B. Function of the Valve Under All Conditions

The information required under this heading is usually most difficult to obtain, but it is necessary to know all the conditions under which the valve is to operate. The variation in the pressure drop across the valve is the principal factor. The valve size is determined by the pressure drop. The design features in a valve are useable only through a certain range of pressure drop. For example, the use of a single-seated valve is limited by the pressure drop across

Presented at the New Jersey Section, Instrument Society of America Symposium, "Use and Application of Control Valves," April 1, 1952.

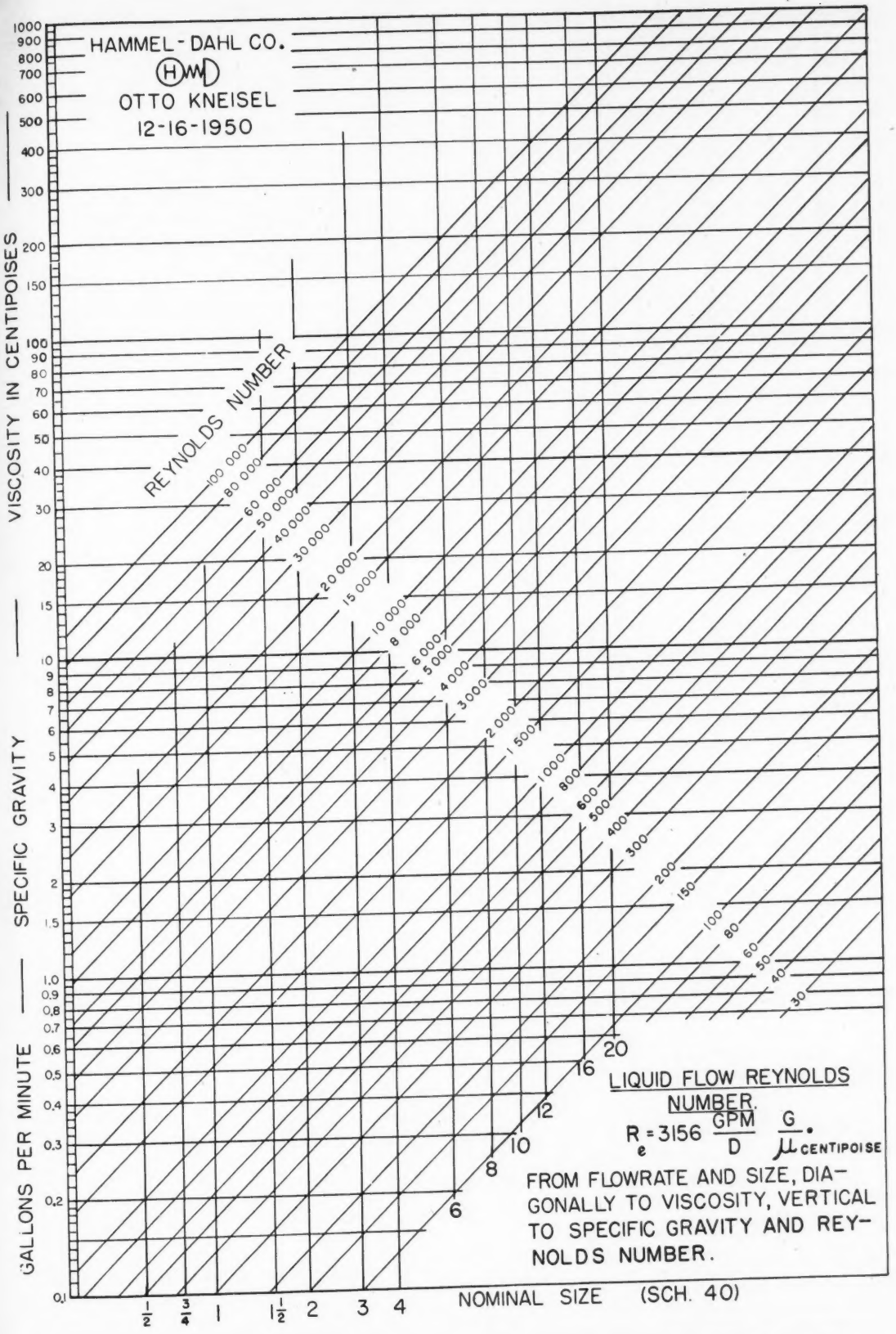


Fig. 1. Chart for determination of Reynolds Number from flow rate, viscosity, specific gravity, and nominal valve size.

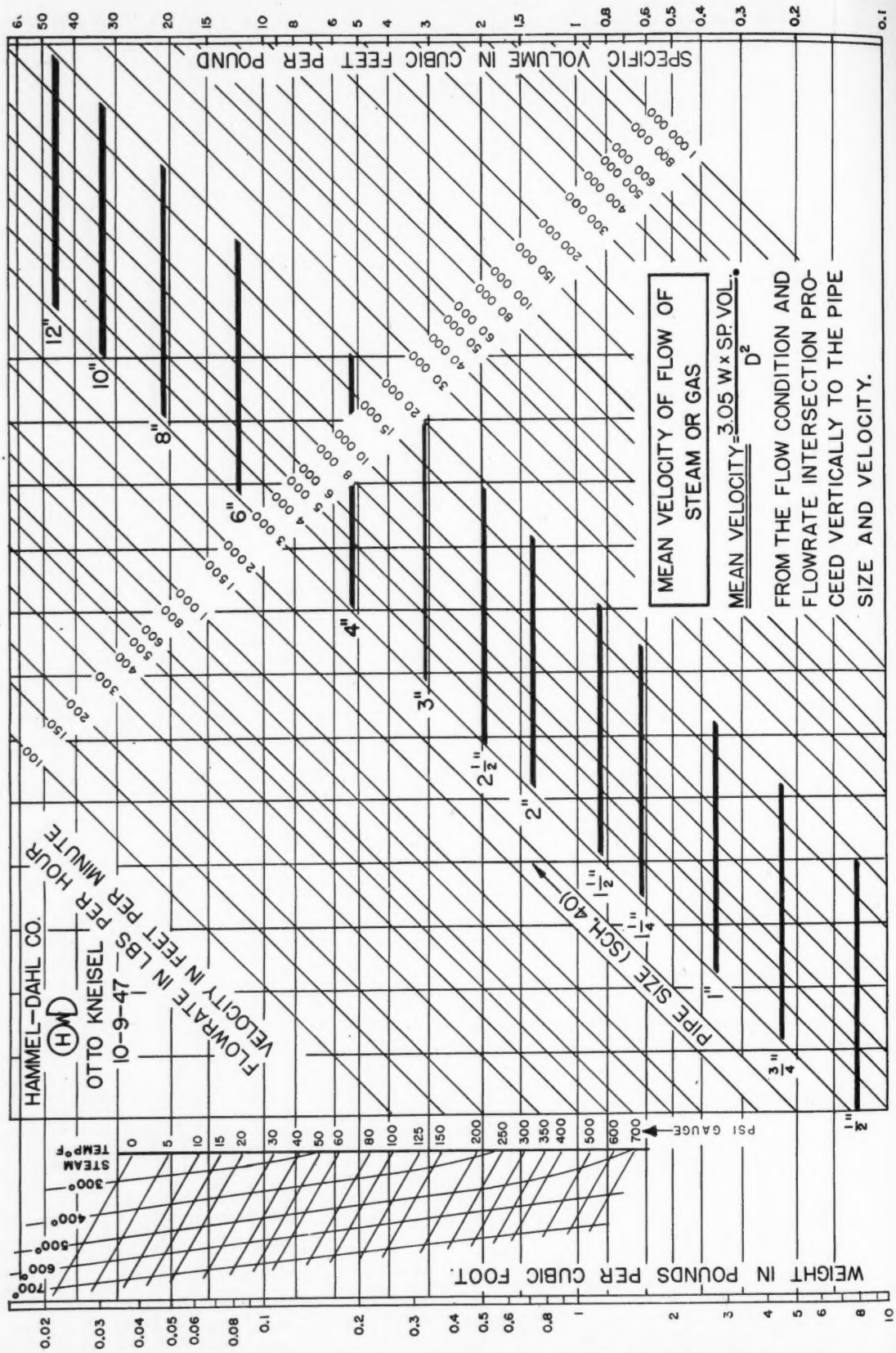

MEAN VELOCITY OF FLOW OF STEAM OR GAS
MEAN VELOCITY = 3.05 W x SP. VOL. / D²
FROM THE FLOW CONDITION AND FLOWRATE INTERSECTION PROCEED VERTICALLY TO THE PIPE SIZE AND VELOCITY.
SPECIFIC VOLUME IN CUBIC FEET PER POUND
WEIGHT IN POUNDS PER CUBIC FOOT
PIPE SIZE (SCH 40)
PSI GAUGE
STEAM TEMP °F
FLOWRATE IN LBS PER HOUR
VELOCITY IN FEET PER MINUTE
HAMMEL-DAHL CO.
OTTO KNEISEL
10-9-47

Fig. 2. Chart for determination of gas or steam mean velocity from flow rate, flow condition, and pipe size.

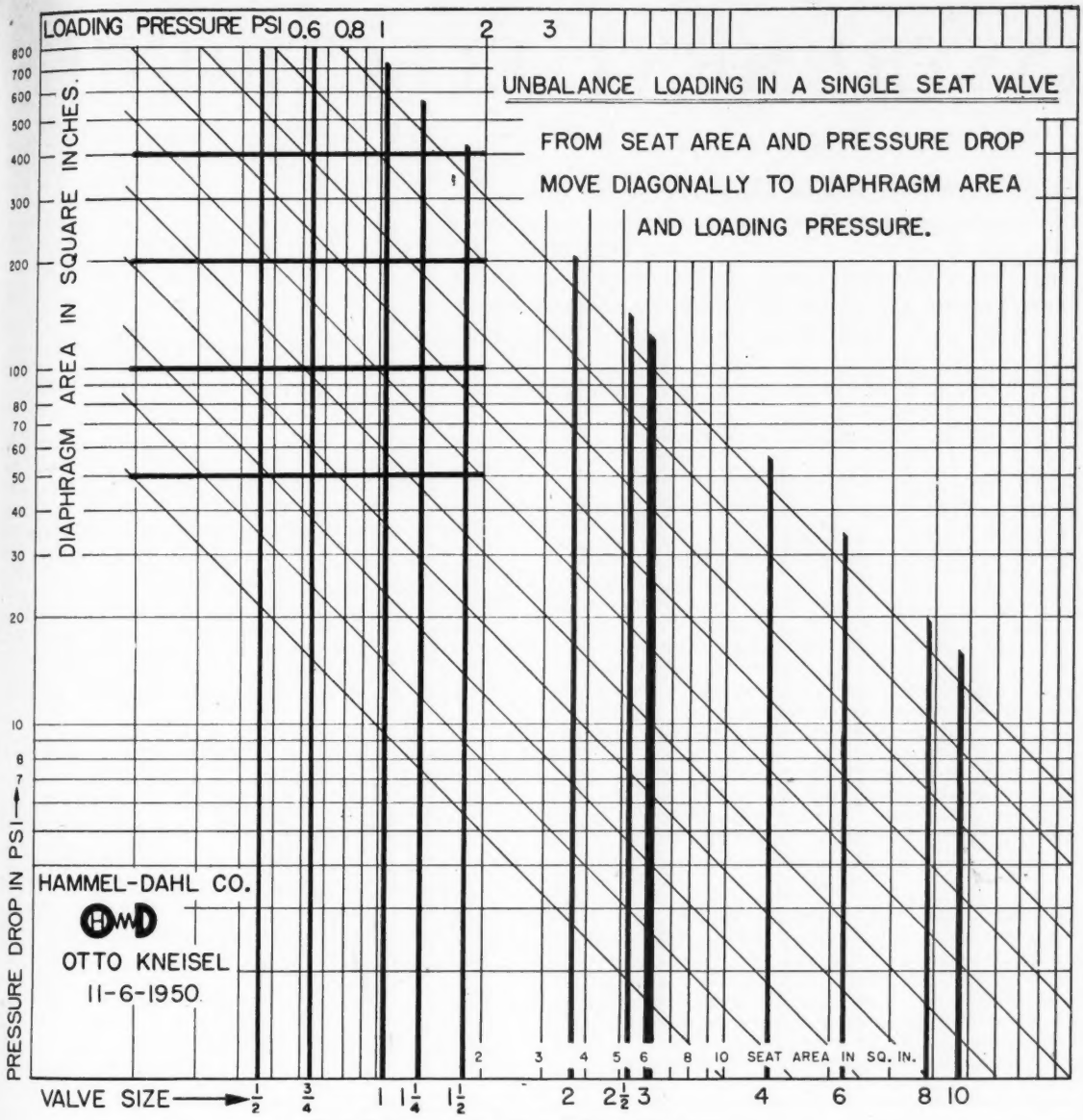

LOADING PRESSURE PSI 0.6 0.8 1 2 3
UNBALANCE LOADING IN A SINGLE SEAT VALVE
FROM SEAT AREA AND PRESSURE DROP
MOVE DIAGONALLY TO DIAPHRAGM AREA
AND LOADING PRESSURE.
DIAPHRAGM AREA IN SQUARE INCHES.
800 700 600 500 400 300 200 100 80 70 60 50 40 30 20 10 8 7
PRESSURE DROP IN PSI
HAMMEL-DAHL CO.
OTTO KNEISEL
11-6-1950
2 3 4 5 6 8 10 SEAT AREA IN SQ. IN.
VALVE SIZE ½ ¾ 1 1¼ 1½ 2 2½ 3 4 6 8 10

Fig. 3. Unbalance loading in a single-seat valve.

the valve. When the valve is closed, with the pressure tending to force the plug off the seat, the unbalance force is equal to the fluid differential-pressure times the seat-ring-orifice area. This force must be opposed by an equal and opposite force in order to hold the plug in position. As the plug is withdrawn from the seat, this force decreases rapidly. The unbalance force caused by the pressure drop should be such that it can be overcome by less than 2-psi. air loading on the diaphragm motor.

11. Valve to open or close on *air failure*. This determines the action of the valve. All valves are constructed one way or the other and some are reversible from one action to the other. It is important that the action of the instrument and the action of the valve give the required control. In many applications it does not matter whether a valve goes open or closed on air failure, but on steam lines the valve usually closes on air failure. A consideration of the system will determine the action least objectionable on air failure.

12. *Operating range*. The operating range of the valve usually matches the output pressure range of the air-operated instrument controller. The standard range is 3 to 15 psi. Other ranges are available. The range is determined by the spring in the diaphragm motor.

13. *Fluid temperature, minimum, normal, and maximum.* It is necessary to know the temperature range in order to consider the effect of temperature expansion on the moving parts in the valve. The stuffing-box packing and lubricant must be satisfactory for the fluid material and the temperature. Suppliers give temperature ranges for these materials. It may be necessary to consider radiation bonnets to cool the stuffing box to temperatures at which commercially available packing and lubricant may be used.

14. *Ambient temperature range.* The diaphragm air-motor commonly has a rubber or neoprene diaphragm. These diaphragms can be used in an ambient temperature range of 20 to 150 deg. F. Silicon rubber with glass fiber insert can be used in an ambient temperature up to 300 deg. F.

15. *Tight shut off* is or is not required. Control valves are designed for throttling service and not for shut off. The design features in the construction of a throttling control

Continued on page 918

INSTRUMENT ELECTRONICS

Basic circuits for shaping waves and signals include the modulator, demodulator, limiter, clamper, gater, counter, and phase shifter. Modulators and demodulators for amplitude, frequency, phase, and pulse-time modulation are discussed in this installment. Limiters, clampers, gaters, counters, and phase shifters are discussed next month.

By MILTON H. ARONSON
Technical Editor, *Instruments*

XI. SIGNAL-SHAPING CIRCUITS

THE three basic functions of electron tubes—rectification, amplification, and oscillation—have been discussed. All other functions are but modifications of these basic functions for specific purposes. For example, an oscillator can produce a sinoidal radio-frequency signal, or sine wave, that can propagate through space when radiated from an antenna. Such a wave is called a radio-frequency carrier. However, it is necessary to change the wave in amplitude, frequency, or phase in order to deliver a message via the wave. The process of superimposing a signal on a radio-frequency carrier wave is called *modulation.* Similarly, the process of recovering the signal from the carrier wave is called *demodulation.* These are two basic wave-shaping functions. Other common circuits include (1) limiters, which remove one extremity or the other of a wave, (2) clampers which change the reference level of a wave, (3) peakers, which shape pulses, (4) phase shifters, (5) counters, and (6) gating circuits.

Modulation

Any method by which information can be superimposed on a radio-frequency carrier wave is a modulation method. A sinoidal wave has three basic characteristics—amplitude, frequency, and phase. A wave whose amplitude is varied in accordance with a desired signal is called *amplitude modulated;* one whose frequency is varied is called *frequency modulated;* one whose phase is varied is called *phase modulated.* A new method of modulation coming into common use consists of varying the spacing of pulses. This is called *time, pulse-time* or *pulse-position modulation.* Each of the four methods has its inherent advantages and disadvantages.

Nature of a Modulated Wave

As explained in Chapter 4, any wave that is *not* a pure sine wave consists of a number of sine waves of definite frequencies, phases, and amplitudes. Thus, when a sine wave is modulated (changed) in any way, it consists of a number of waves of different frequencies. The range of frequencies in any wave is called the *bandwidth* of the wave. The bandwidth of radio waves is particularly important because there are so many different radio transmitters that it is necessary to minimize the bandwidth (range of frequencies) of every transmitted signal in order to prevent it from interfering with other signals transmitted at nearby carrier frequencies. Thus narrow bandwidth is a desirable feature in a modulated wave.

Unfortunately, bandwidth increases with the amount of information imposed on a carrier wave. Thus a compromise must always be made between the amount of information transmitted and the bandwidth permitted by authorities. The advantage of amplitude modulation over frequency

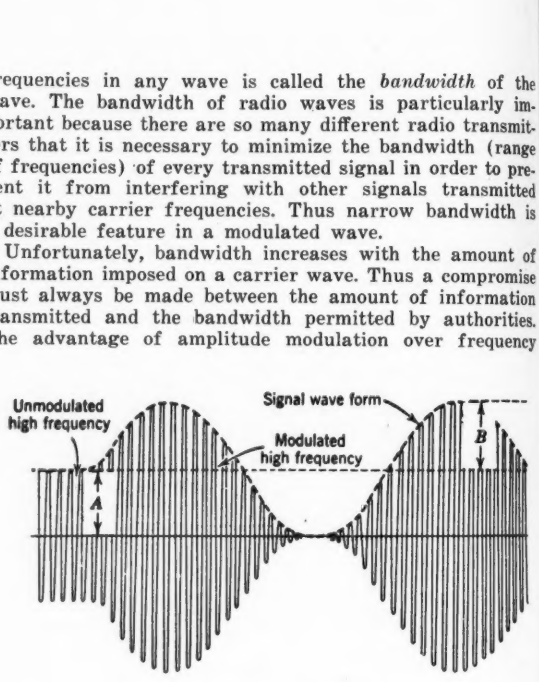


Fig. 11-1. An amplitude-modulated wave.

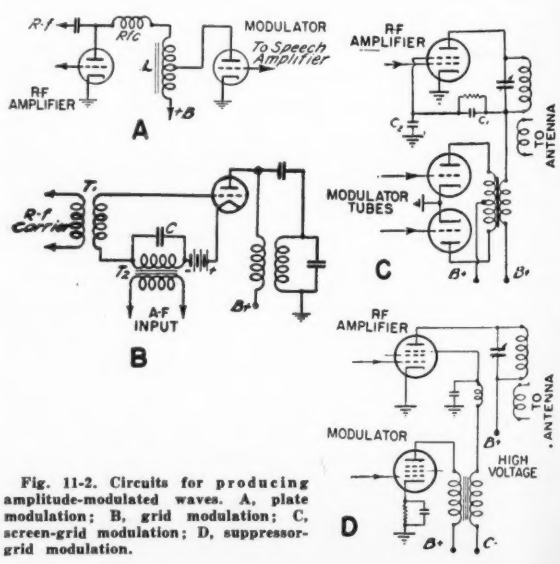


Fig. 11-2. Circuits for producing amplitude-modulated waves. A, plate modulation; B, grid modulation; C, screen-grid modulation; D, suppressor-grid modulation.

ANSWERS TO QUIZ X.—OSCILLATOR CIRCUITS

10- 1.	(a)	10- 8.	(d)	10-15.	(b)	10-22.	(c)	10-29.	(b)
10- 2.	(d)	10- 9.	(c)	10-16.	(b)	10-23.	(a)	10-30.	(c)
10- 3.	(c)	10-10.	(d)	10-17.	(a)	10-24.	(d)	10-31.	(d)
10- 4.	(c)	10-11.	(a)	10-18.	(d)	10-25.	(d)	10-32.	(a)
10- 5.	(d)	10-12.	(a)	10-19.	(a)	10-26.	(d)	10-33.	(b)
10- 6.	(b)	10-13.	(d)	10-20.	(b)	10-27.	(d)	10-34.	(d)
10- 7.	(b)	10-14.	(c)	10-21.	(a)	10-28.	(d)	10-35.	(c)
		10-36.	(d)	10-37.	(c)	10-38.	(d)		

Test Items for XI.—Page 930.

and phase modulation is that the amplitude-modulated (a-m.) wave requires least bandwidth.

Amplitude-modulated Waves

An amplitude-modulated wave is shown in Fig. 11-1. The amplitude is varied in accordance with the signal to be transmitted, which is a wave of lower frequency, such as an audio signal. The shape of the modulated wave represents the *product* of the carrier wave and the signal.

There is a basic trigonometric expression for the product of two sine waves:

$$(\sin x)\ (\sin y) = \tfrac{1}{2}\cos\ (x-y) - \tfrac{1}{2}\cos\ (x+y)$$

This says that the product of two sine waves consists of two other sine waves. If x and y are the frequencies of carrier and signal, respectively, then the resultant wave has frequencies equal to the *sum* and *difference* of the two frequencies. These waves are called *sideband* frequencies. Thus the maximum required bandwidth of an amplitude-modulated wave is *twice* the highest modulating frequency. This is obvious because the range in frequencies from $x-y$ to $x+y$ is $2y$.

An amplitude-modulated wave actually consists of a carrier and two sidebands for each modulating frequency—one sideband above and one below the carrier in frequency. The sidebands are not mathematical devices—they are the waves that carry the signal; they can be filtered out and used individually if desired.

The *degree of modulation* of an a-m. wave is the ratio of the maximum deviation in amplitude above normal to the normal amplitude, expressed in percent. Thus the degree of modulation of the wave shown in Fig. 11-1 is $B/A \times 100$, or 100 percent. This usually is the maximum modulation permissible because of bandwidth considerations. When transmitting radio signals it is desirable to use this maximum amount of modulation because a stronger signal is received at the receiver.

The advantage of amplitude modulation is relatively narrow bandwidth. The basic disadvantage is that atmospheric disturbances also are amplitude-modulated radio signals that can mask the desired signal.

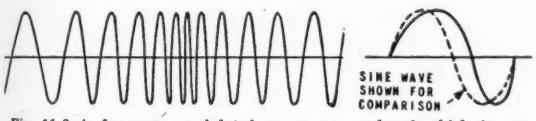
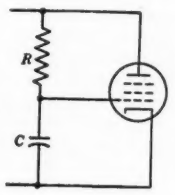


Fig. 11-3 A frequency-modulated wave, one cycle of which is compared with a sine wave of constant frequency.

Fig. 11-4. Reactance tube with R-C network to make tube an effective inductance. Network causes grid voltage and hence plate current, to lag plate voltage.



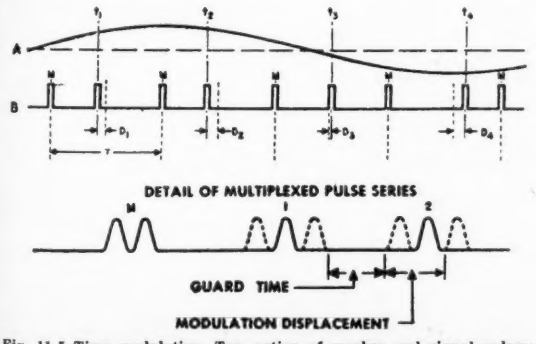


Fig. 11-5 Time modulation. Top, action of marker and signal pulses; bottom, two signal pulses used with one marker pulse for a 2-channel system.

Modulation circuits. Fig. 11-2 shows methods for producing amplitude modulation. The circuit in Fig. 11-2,A is a plate-modulation circuit because the audio modulating signal is applied to the plate of the r-f. amplifier. Note that the modulating signal is effectively in series with the B supply for the r-f. amplifier. As the audio signal increases and decreases the effective B supply, it changes the gain of the tube, and hence the amplitude of the signal.

Fig. 11-2,B shows *grid-modulation*, in which both the modulating a-f. signal and the carrier r-f. signal are applied to the grid. Note that both signals are effectively in series.

Modulation can be accomplished also by applying the modulating signal to the screen grid or suppressor grid of a pentode, as in Fig. 11-2,C and D.

Frequency and Phase Modulation

Frequency modulation and phase modulation are alike in principle, theory, and circuitry. This is shown in Fig. 11-3, which shows that each cycle of the wave whose frequency is being changed is effectively changed in phase at each instant. Thus an f-m. receiver can receive a p-m. signal. The basic difference is in the method of modulation.

The bandwidth required by frequency-modulated (f-m.) and phase-modulated (p-m.) waves is much larger than for a-m. waves because each modulating frequency (y) produces many pairs of sidebands with frequencies of $x \pm y$, $x \pm 2y$, $x \pm 3y$, etc. (x is the carrier frequency). The number of sidebands depends on the frequency deviation imposed on the carrier. Thus f-m. and p-m. transmitters are limited to a definite frequency excursion on each side of the carrier frequency.

Reactance tubes. In order to cause a wave to change in frequency, it is necessary to change an inductance or capacitance in the resonant circuit controlling the oscillation. This is done usually by making a tube act like an inductor or a capacitor. Such tubes are called *reactance tubes.*

A reactance tube is simply an amplifier with a network connected between plate and grid to cause the plate current to lead or lag the plate voltage by 90 degrees, thus making the tube an effective inductance or capacitance. The network can be an *R-C* or *R-L* network. The *R-C* network shown in Fig. 11-4 makes the tube act like an inductance. The network makes the tube act like an inductance because the grid voltage is shifted in phase so that the resulting plate current lags the plate voltage by 90 degrees, which is the basic action of an inductance. When the modulating signal is applied to the screen grid of the pentode, the tube passes more or less current, thereby acting like a variable inductor. If the tube is connected directly across a resonant tank, it can control the frequency of the tank. It is used in signal generators that produce a swept frequency; a sawtooth wave applied to the screen grid causes the tube to change the frequency of the generator in a linear manner.

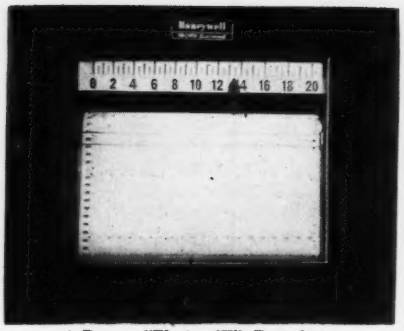
The advantage of frequency and phase modulation is that external factors seldom disturb the frequency or phase of a signal, thus giving a high signal-to-noise ratio in received signals. The disadvantage is large bandwidth, which requires that high carrier frequencies be used. For example, the commercial broadcast f-m. band is set at 98 to 108 Mc., which frequencies do not have large range, whereas the broadcast a-m. band is from 550 to 1500 kc., which frequencies have long range.

Pulse-time Modulation

In pulse-time, or time modulation (t-m.), a pair of sharp pulses is repeated at fixed intervals (T) as shown in the curve B of Fig. 11-5. The first, or *marker* pulse (M), occurs at definite intervals; however, the position of the second, or *signal* pulse, depends on the signal that is to be transmitted or telemetered. The signal voltage (A) is shown at the top of Fig. 11-5.

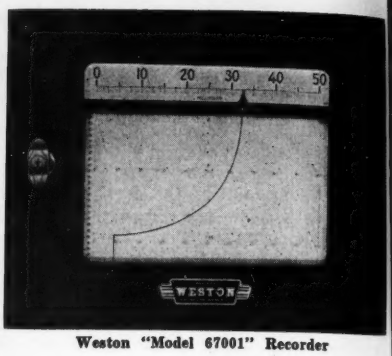
Enough pulse "samples" must be taken to reproduce the desired signal. Thus the rate of repetition of the pulses must be at least 2½ or 3 times as much as the highest frequency to be transmitted.

Continued on page 926



Brown "ElectroniK" Recorder

Bailey "Pyrotron"



Weston "Model 67001" Recorder

Fundamentals of
ELECTRONIC RECORDERS

By JOHN E. WITHERSPOON
Aerophysics Field Laboratory, North American Aviation, Inc.

ELECTRONIC recorders are replacing galvanometer and mechanically operated instruments in both old and new installations because of their inherent advantages, which are as follows:

1. Electronic recorders can record operating variables that take place at great distances from the instrument. In d-c. millivolt recorders this is a direct result of the high input-impedance which is inherent in electronic amplifiers. Whereas galvanometer-type recorders have an input impedance of less than 100 ohms and therefore draw power from the thermocouple or sensing element, the electronic recorder is a high-impedance device (7,000 ohms or greater under unbalance conditions and infinite at balance) and draws little or no power from the sensing element.

2. Electronic recorders have high sensitivity. They can be used to measure voltage differences of the order of one ten thousandth (0.0001) of a volt or smaller if necessary. Any physical condition which can be converted to a proportional electrical change in voltage, resistance, capacitance, or reluctance can be recorded.

3. Electronic recorders can be made accurate to ± ¼ percent of full scale.

4. A fast response time can be achieved in electronic recorders. Even the slowest can reach a balance point within 10 seconds even if the pen must move all the way across the scale. In some recorders this time has been reduced to less than one second.

5. The electronic recorder is versatile. It usually has a simple arrangement for changing the useful range. It can be used readily for various types of measurements. For example, a thermocouple-actuated temperature recorder can be used to measure d-c. potentials from any source by minor changes in the input circuits.

6. Variables which change at high frequencies can be measured by the use of electronic recorders and associated equipment. The recorder may not follow the fluctuations, but it will indicate an average value. Mechanical recorders may be limited by the resonant frequency of the Bourdon-tube drive-sensing element, which may be 600 cycles per second or less. By using high-resonant-frequency sensing-elements in electronic recorders, measurements can be made of variables which are changing at frequencies up to 2000 cycles per second without inaccuracy of the average value.

7. Electronic recorders need less routine maintenance and trouble shooting than mechanical recorders.

These advantages may not always be necessary for a particular application. The galvanometer-type recorder is cheaper and does not require 110-volt a-c. power. Where there is danger of explosion because of the atmosphere, a mechanical recording system may be cheaper and simpler than explosion-proof electronic equipment.

Direct-current Millivolt Recorders

The most widely used electronic recorders are d-c. millivolt recorders that record the output of thermocouples. D-c. millivolt recorders may be used also with pickups that sense pH (Beckman cell), fluid flow (Potter Aeronautical Co. electromagnetic flow-sensing element), and speed of rotation (tachometer generators). With voltage dividers, even high d-c. potentials can be measured.

The block diagram of Fig. 1 gives the major components of d-c. millivolt recorders. These instruments use the continuous balance principle—any change in signal from a sensing element causes an equal and opposite change in the recorder. The sensing element—a thermocouple, pH cell, flow-sensing element, or tachometer generator—generates a d-c. voltage with some definite relation to the variable being measured.

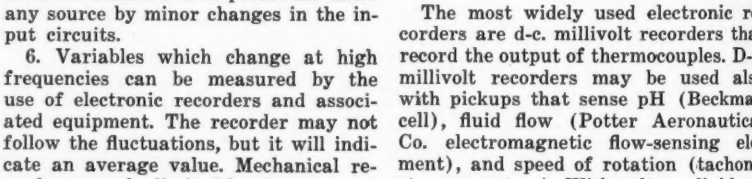
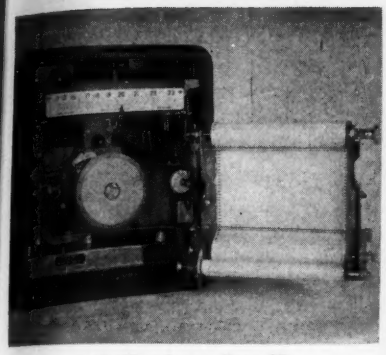


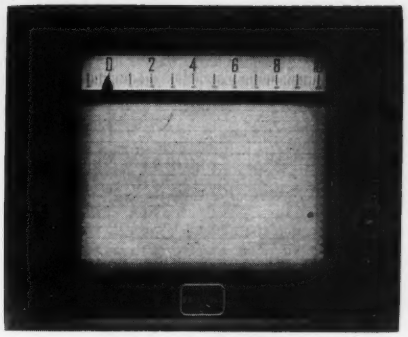
Fig. 1. Block diagram of d-c. millivolt recorder.

*Presented at the Los Angeles Harbor Junior College "Instrument Maintenance Short Course," Nov. 14, 1951.



L & N "Speedomax Type G"

Foxboro "Dynalog"



Bristol "Dynamaster"

The input circuit contains filters that eliminate spurious a-c. signals which may be impressed on the lead wires to the sensing element. These are resistors and capacitors arranged in a 60-cps. filter network; if other frequencies are present as interference, additional filtering components may be added. In addition to the filter, a voltage divider of precision resistors may be used at the input to attenuate high-level d-c. signals to the input requirements of the recorder.

The measuring bridge and converter stage is the point at which actual voltage sensing takes place. The input to this stage is a d-c. signal from the input circuit. The output of the stage is an a-c. signal which represents any unbalance of the measuring bridge. The alternating-current characteristics of the signal are derived from the action of the *converter*, which is sometimes called the *chopper*.

The amplifier is the "electronic" part of the recorder. It amplifies the small a-c. signal put out by the converter to the power necessary to drive the balance motor. The amplifier is capacity coupled and amplifies only alternating-current signals.

The output of the amplifier is fed into a *demodulator* stage. This function often is combined with that of the power-output stage of the amplifier. The demodulator determines whether the balance motor drives the recorder pen up or down scale in response to the signal.

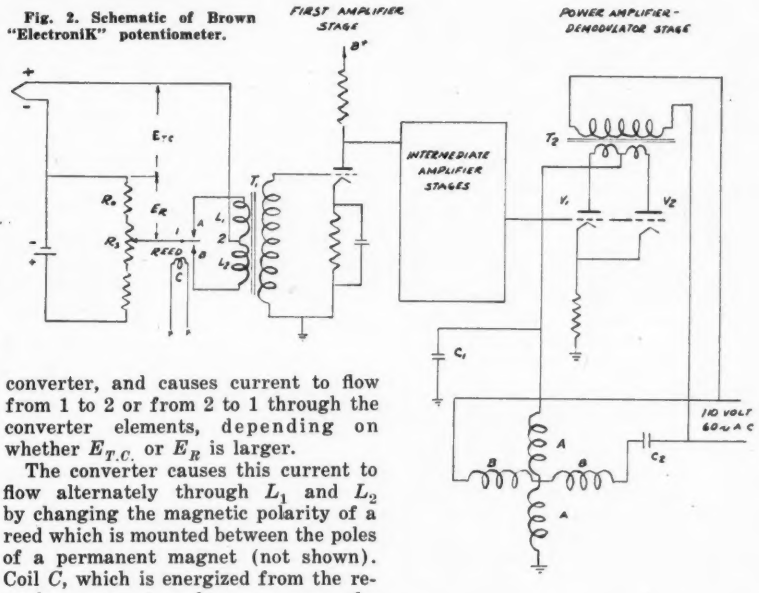
The *balance motor* is a two-phase induction motor which is, therefore, reversible. It serves two functions: First, it drives the recording pen in the proper direction; second, it drives a wiper on the potentiometer bridge slidewire to balance the signal from the sensing element.

Brown "Electronik" Potentiometer

The Brown "Electronik" Recorder (Fig. 2) is an example of a continuous-balance potentiometer that uses an electronic amplifier between the balance motor and measuring bridge. For simplicity, only the input and output stages of the amplifier are shown. The intermediate capacity-coupled amplifier stages have no effect other than raising the voltage and power level of the error signal from the measuring bridge. A description of the operation of this instrument follows:

The voltage of the thermocouple ($E_{T.C.}$) is compared with the voltage E_R impressed by the battery across R_o and R_s to the wiper contact. The algebraic difference between $E_{T.C.}$ and E_R appears between points 1 and 2 of the converter, and causes current to flow from 1 to 2 or from 2 to 1 through the converter elements, depending on whether $E_{T.C.}$ or E_R is larger.

Fig. 2. Schematic of Brown "ElectroniK" potentiometer.



The converter causes this current to flow alternately through L_1 and L_2 by changing the magnetic polarity of a reed which is mounted between the poles of a permanent magnet (not shown). Coil C, which is energized from the recorder power transformer, causes the reed to vibrate. The reed moves between the magnet poles and makes contact with either point A or point B to complete the circuit from 1 to 2. This "chopping" action causes an alternating current to be induced in the secondary of transformer T_1 at the frequency of driving coil C.

The signal that appears across the secondary of transformer T_1 is either in phase or 180 degrees out of phase with the current through coil C, depending on the direction of current between points 1 and 2. This signal is amplified with 180-degree phase change by the first amplifier stage. The signal is further amplified and changed in phase by another 360 degrees so that the signal at the common grids of the power-output stages (V_1 and V_2) is actually 180 degrees out of phase with the signal at the grid of the first amplifier.

The power-output stage of the amplifier is also the demodulator of this recorder. The plate voltages of V_1 and V_2 are supplied from transformer T_2. Depending on which plate voltage is in phase with the grid voltage, one tube or the other can conduct for a half of each timing-voltage cycle. Whether the pulses are in the first or second half cycle of the timing signal depends on which tube is conducting. Phase sensing is thus achieved and is a function of the output signal of the measuring bridge, which in turn is a function of the amplitude of the voltage from the sensing element.

The half-cycle pulses of current passed by the demodulator tubes also pass through the A winding of the balance motor to ground to complete the circuit. Capacitor C_1 across this winding is selected so that the combination of the A-winding inductance and C_1 resonates at 60 cycles per second. This gives a signal on the A winding which lags the half-cycle pulses of current from the output tubes by 90 degrees.

The 60-cycle current flowing in the *A* winding of the balance motor is thus either 90 degrees leading or lagging the 110-volt 60-cycle power which is used as the timing standard throughout the recorder. As this power is impressed also on the *B* winding of the balance motor, and because of the inductive nature of the motor winding, capacitor C_2 is connected in series with the winding to bring the current in the winding into phase with the power supplied to the recorder. When one or the other of the demodulator tubes conducts, the balance motor rotates in a direction determined by which of these tubes conducts.

The balance motor rotates until it moves the wiper of the slidewire, R_s, to a point where E_R is equal to $E_{T.C.}$. At this point there is no error signal to the amplifier and the balance motor stops. The recorder pen also is moved to a point which indicates the thermocouple output.

A-C. Bridge Recorders

Another commonly used method of sensing temperature operates on the principle that certain materials change in electrical resistance in some definite relation to their temperature. The a-c. bridge recorder is used in this type of measurement. The term "a-c. bridge" is derived from the bridge that is the input circuit of the recorder. The bridge-type recorder measures resistance changes and relates them to actual temperatures by proper calibration.

This type recorder can be used also to measure pressure (Statham pressure pickup), force (Baldwin load cells), torque (Baldwin Torquemeter), flow (Foxboro d/p Cell and orifice-meter combination), acceleration (Statham accelerometer) and any other physical changes that can be converted to change of electrical resistance.

Fig. 3 shows the major components of a-c. bridge recording instruments. The instrument operates on the principle of continuous balance of the measuring bridge. However, as the bridge compares resistances rather than voltages, it must have an exciting voltage applied across it. This is an alternating-current signal. The input circuit comprises this bridge and its exciting voltage.

As any unbalance of the measuring bridge causes an alternating current, no converter stage is necessary. The amplifier is a capacity-coupled high-gain unit. The demodulator determines the direction of rotation of the balance motor in accordance with the signal from the measuring bridge. The balance motor is a two-phase induction motor; the phase difference between the signal to the separate windings determines the direction of rotation. The motor drives a recording pen and the wiper of the measuring-bridge slidewire, which rebalances the bridge.

Bailey "Pyrotron"

The Bailey Meter Company uses the change of electrical resistance with temperature of platinum wire as the sensing element in its a-c. bridge temperature recording system, the "Pyrotron" (Fig. 4).

The platinum-wire temperature-sensing element (T) is connected in the a-c. bridge of the input circuit. The bridge is energized from a 7.5-volt a-c. winding of the input power transformer, T_1. Resistors R, R_A, and R_B are selected in conjunction with the slidewire resistance (R_s) and the resistance characteristics of T to establish the desired range of the recorder.

The voltage output of the bridge is phase sensitive to unbalance caused by changes in resistance of T. When T increases with increase in temperature, the voltage output across the bridge (between point 1 and ground) is in phase with the 7.5-volt a-c. exciting signal. When T decreases in resistance, the small voltage output between point 1 and ground is 180 degrees out of phase with the 7.5-volt signal.

The amplifier has a 360-degree phase shift from the grid of the first amplifier to the grid of the power-output and demodulator stage. Thus the signal on the grid of the latter is in phase with the signal between point 1 and ground.

The power-output and demodulator stage consists of a dual-triode tube (V_1 and V_2) whose plates are tied through the controlling d-c. coils of separate saturable reactors to opposite ends of a 110-volt secondary winding on power transformer T_1. Thus, the plate voltages of V_1 and V_2 are 180 degrees out of phase.

Under "no-signal" condition, both output tubes conduct during alternate half cycles of the input power. Capacitors C_1 and C_2 make the current through the a-c. coils of the saturable reactors more steady than the pulses conducted by the tubes. When the d-c. coils carry current, the a-c. coils conduct and the full voltage of the autotransformer primary of power transformer T_1 is applied to the two windings of the balance motor. As these motor windings are energized in phase with one another, the motor does not turn.

With a signal at the grid of the power-output tubes that is in phase with the plate voltage of V_1, V_1 conducts pulses of current and V_2 is cut-off. The secondary of X_1 now conducts and current flows through L_1 in phase with the supply voltage of the recorder. Current also flows through C and L_2 but, because of C, leads the line voltage by almost 90 degrees. Thus the motor rotates, driving the recording pen and slidewire until the input circuit is rebalanced.

If the signal from the input circuit is in phase with the plate voltage of V_2, the same action takes place as when V_1 conducts except that capacitor C is now in series with L_1 so that the current through L_1 leads the current through L_2 and the motor rotates in the opposite direction to rebalance and to record the temperature.

DISCUSSION

Mr. Feree, Brown Instruments Div.

In checking the "Electronik" Potentiometer, possible tube troubles should be eliminated first. Brown feels that the best method of doing this is to replace each tube individualy with a known good tube. (Note: Originally, Brown recommended that all replacement tubes be supplied by them. Now they recommend only that the tube of the first amplifier stage be so treated and this for narrow span recorders only. The tubes they supply have been checked for interelectrode strays. This is not done on commercial tubes.)

Continued on page 916

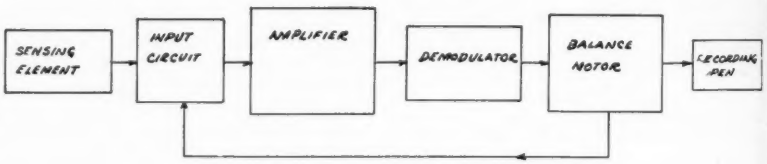


Fig. 3. Block diagram of a-c. bridge recorder.

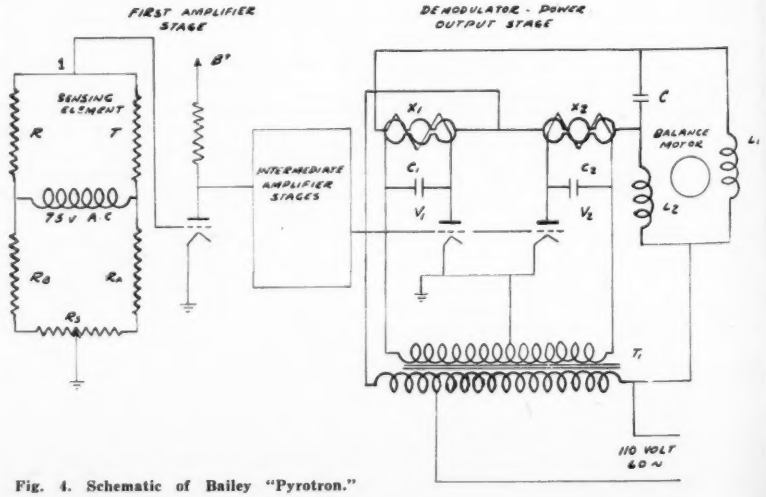


Fig. 4. Schematic of Bailey "Pyrotron."

INSTRUMENT SOCIETY of AMERICA Journal

National Office: 1319 Allegheny Avenue, Pittsburgh 33, Pennsylvania

Vol. 8 July 1952 No. 7

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THE MANAGER'S PAGE

Percy V. Jones, Jr.

AS the time for the ISA's Seventh National Instrument Conference and Exhibit approaches and more information concerning the program comes to light it becomes increasingly apparent that the effort expended by Technical Committee Chairmen and others is resulting in a record conference that, in variety, size, and excellence will serve as a worthy goal for future National ISA activities.

Portions of the program have previously been reported in these pages, but a careful perusal of the Preliminary Program, which should be in your hands about the same time as this issue of the Journal, is required for a full appreciation of what this year's meeting has to offer the visitor.

Earlier announcements understated the facts concerning the Technical Sessions, for several Committees have expanded their programs beyond all expectations. More new features have recently been added. Fortunately, facilities at Cleveland Auditorium are well able to accommodate this expanded program.

An additional feature this year will be an ISA Members' Luncheon scheduled for 12:00 P.M. on Wednesday, September 10th. All ISA members, with their wives and guests, are invited to attend and take this opportunity to meet their National Officers. A special Restaurant is to be set up in the Auditorium for this and other special functions. Tickets may be purchased in the lobby of the Auditorium until the evening of Tuesday, September 9th. The Annual meeting of the Membership at 1:30 P.M. will follow this luncheon. At this meeting, Section charters will be presented to representatives of the new Sections that have joined the Society since last September. As this issue goes to press, five new sections will be represented. However, it is hoped that this number will increase before September.

Another added attraction of this year's Conference will be two Open-session Panel Forums on "Frontiers of Instrumentation" sponsored by the ISA Instrument Industry Committee. The first session is scheduled for Monday afternoon and will follow the Exhibitors Luncheon to be held in the Auditorium Restaurant. Outstanding Science Editors of national publications will lead a discussion and answer questions by instrument users and manufacturers on where they believe science is heading and what the public is expecting from the Scientific Instrument Industry.

The second session at 2:30 P.M. on Wednesday will follow the ISA Members' Luncheon and will be held in the same room. This meeting will feature outstanding technical authorities who will lead a discussion and answer questions on required new developments as seen by the user in selected fields of instrumentation. Recognition of the fact that manufacturers can design and make the right tools only if users tell where they are going and what they need will be emphasized in this Session.

From the foregoing and previously reported information, it should be clearly evident to any instrument man that he cannot afford to miss the ISA Seventh National Instrument Conference and Exhibit. There he will meet the leaders in his field, see the latest in instruments, and learn about the latest practices in Instrumentation. All papers will not be published, so there is but one way to get this information—that is to be there.

HELP WANTED

Do you have any extra copies, or copies you are not using, of ISA Proceedings. Volumes 1 through 4? We are looking for unmutilated copies. Please write Percy V. Jones, Manager, Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Penna.

Country Fair Party Planned for Cleveland

Social highlight of the Seventh National Instrument Conference and Exhibit will be a County Fair Party to be held Wednesday Evening, September 10th. This gala event which will occupy the entire mezzanine floor of the Hollenden Hotel is shaping up to be the most novel to date with a variety of eye-opening entertainment to supplement the usual attractions of a country fair but without the cows, pigs, chickens, and homemade jelly. Good prizes may be won by all carnival booths and three lucky winners will take home sensational door prizes. One of these prizes is a television set donated by Fred A. Lennon, General Chairman of the Cleveland Host Committee.

An orchestra will provide music for square dancing in the Ballroom and the beer is "on the house," as is the midnight buffet. There are no dress requirements for this evening of fun so pack your sport shirt and slacks and "Come to the Fair." Tickets will be on sale at the Auditorium at $3.00 each for men and $2.00 for the ladies.

National Committees and Chairmen

Society Structure & Planning—Nelson Gildersleeve.
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Instrument Industry—Charles L. Saunders
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Meetings and Exhibits—E. J. Grace, Jr.
Publications—C. W. Covey
Sections and Membership—M. D. Shriver
Employment—P. V. Jones
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Public Relations—Douglas M. Considine
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Educational Committee—Prof. Robert J. Jeffries
Historical—L. M. Susany
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Analysis Instrumentation—Axel H. Peterson
Instrumentation for Inspection & Gaging
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Instrumentation for Production Processes
W. H. Brand
Instrumentation for Transportation
F. H. Catlin
Medical Instrumentation—Dr. H. J. Morowitz
Meteorological Instrumentation
Christos Harmantas
Radiation Instrumentation—Richard W. Johnston
Geophysical Instrumentation—Dr. David Muzzey
***Physical Properties Measurement**
Aeronautic Instrumentation—Robert Tozier
Recommended Practices—A. V. Novak

**Chairman not assigned*

Ladies' Program for Cleveland Show

An interesting program has been arranged by the Ladies Welcoming Committee for the wives and daughters of men attending the Seventh National Instrument Conference and Exhibit.

Advance registration will take place between 2:00 P.M. and 6:00 P.M., Sunday, September 7, at the special Ladies Registration desk in the Hotel Cleveland. Later arrivals may register between 11:00 A. M. and 5:00 P.M. Monday, September 8 through Thursday, September 11 and on Friday, September 12 from 11:00 A.M. through 2:00 P.M., at either the Hotel Cleveland or the Cleveland Auditorium.

Ladies are urged to register as soon after arrival as possible in order that the Committee will have the local address of visiting ladies and be able to contact them during their stay in Cleveland.

The program is as follows:

Monday, Sept. 8 — 4:00 P. M. Ladies Welcoming Tea.

Tuesday, Sept. 9 — 1:30 P. M. Tour of Nela Park, leaving from Hotel Cleveland. Tickets may be obtained at Ladies Headquarters, Hotel Cleveland.

Wednesday, Sept. 10 — 12:30 P. M. Ladies invited to attend ISA members' Luncheon at Auditorium Resturant. Tickets must be purchased in Registration Lobby of Cleveland Auditorium by Tuesday evening.

Thursday and Friday, Sept. 11-12 — Tickets available for television broadcasts morning and afternoon. Check with Ladies Headquarters for your choice of program.

In addition to the above, informal sight-seeing trips, luncheons, bridge games, etc. will be arranged for any ladies who wish to participate.

There will be no charge for any of the Ladies' Events listed above with the exception of the Members' Luncheon on Wednesday.

Section Secretaries, Meeting Data and Programs

AKRON
Russell F. Marquardt, 1782 Tonawanda Ave., Akron 5, Ohio. Tel: ST-6865
Fourth Tuesday. Meeting 8:15 P.M., U. of Akron, Ayer Hall, Rm. 212-B.

ALBUQUERQUE
W. E. Bostwick, 700 C. North Washington, Albuquerque, N. M.
First Monday, Meeting at 8:00 P.M., Mitchell Hall, Univ. of New Mexico.

ARUBA
J. L. Lopez P. O. Box 203, c/o Lago Oil & Transport Co. Ltd., Aruba, N. W. I. Tel. 2087.
First Tuesday, 7:30 P. M., Engr's Club.

ATLANTA
M. Virgil Davis, 357 Sixth St., N.W. Atlanta, Ga. Tel. EM. 3042
Fourth Friday, Meeting 7:30 P.M., Electric Bldg., Georgia Power Co.

BALTIMORE
G. B. Greer, 631 East 36th St., Baltimore 18, Md. Tel: CHesapeake 6879
Second Friday, Meeting at 8:00 P.M., Engr's. Club of Baltimore.

BATON ROUGE
G. M. McCarroll, 1813 Edinburgh Ave., Baton Rouge 6, La.
Meeting monthly, L.S.U. Physics Bldg.

BOSTON
Stephen E. Lord, 60 Braintree Ave., Quincy 69, Mass. Tel: MA 9-1066
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 7:30 P. M., 99 Club, 99 State St.

CALIFORNIA
Gerald B. Miller, 4622 Halbrent Ave., Sherman Oaks, Calif.
Second Wednesday. Dinner at 6:30 P. M. Meeting at 8:00 P. M.

CAROLINA PIEDMONT
L. Frank Lawrence, Minneapolis-Honeywell Regulator Co., 2400 Wilkinson Blvd.. Charlotte, N. C., Tel: 5-4422
Second Friday, Dinner at 7:30 P.M., Meeting at 8:30 P.M. Cardinal Restaurant, Charlotte, N. C.

CENTRAL ILLINOIS
H. R. Getz, 723 Laura Ave., Peoria 5, Ill. Tel: 4-2800
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
Norman Krone, 123 N. Grant Ave., Indianapolis, Ind. Tel: IRvington 5337
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
H. G. Murray, 169 Durston Ave., Syracuse 6, N. Y. Tel: 9-9259
Third Monday, Dinner at 6:00 P. M., Meeting at 8:00 P. M.

CENTRAL OHIO VALLEY
J. C. Dilliner, 813 Winton Ave., Belpre, Ohio.

CHARLESTON
D. A. Cunningham, 5140 Washington Ave., S.E., Charleston, W. Va. Tel. 55403
First Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M., Kanawha Airport Terminal Bldg.

CHICAGO
Floyd E. Ertsman, Rm. 1420, Fisher Bldg., 343 S. Dearborn St., Chicago 4, Ill. Tel: WE 9-0686
First Monday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Hotel Shoreland.

CHINA LAKE
Beuhring W. Pike, 606-A Essex Circle, China Lake, Calif. Tel: 77782
Third Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS, Conference Room.

CINCINNATI
E. J. Geiser, 3666 Hubble Rd., Cincinnati 24, Ohio Tel. Ja. 5618.
First Monday, Dinner at 6:30 P. M., Meeting 8:00 P.M., Engineering Soc. of Cinn.

CLEVELAND
G. D. Carnegie, 3436 Lorain Ave., Cleveland.
Second Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Cleveland Eng'r. Society, 2186 E. 19th St.

COLUMBUS
Kenneth I. Lea, Battelle Institute, 505 King Ave., Columbus 1, Ohio Tel: UN-3191,Ext. 247.
Third Thursday, Meeting at 8:00 P.M., Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecelia St., Cumberland, Md. Tel: 588-W
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P.M.; Ali Ghan Shrine Country Club, Baltimore Pike.

DENVER
G. M. Peters, 3191 W. Denver Place, Denver 11, Colo. Tel: GRand 9073

DETROIT
Frank R. Davis, Edison Institute, Dearborn, Mich. Tel: LO 1-1620 Ext. 5517
Third Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Rackham Bldg.

EASTERN NEW YORK
Robert W. Carter, Sterling-Winthrop Research Institute, Rensselaer, N. Y. Tel. Albany 5-6251 Ext. 262
First Tuesday, Meeting at 8:00 P.M., Siena College, Loudonville, N. Y. Optional Dinner at 6:00 P.M., Circle Inn, Lathams, N. Y.

GULF COAST
Harold Placette, 2440 Neches Ave., Port Arthur, Texas
Last Tuesday, Meeting at 7:30 P. M., Orange County Courthouse, Orange, Texas.

HOUSTON
A. Costa, 714 East 17th St., Houston 8, Texas.
Last Monday, Meeting at 8:00 P.M., University of Houston Library Building.
July 28, Subject: Fundamental Rules in Instrumenting Various Classes of Equipment. Speaker: Ward O'Connor, Chief Instrument Engineer, Lummus Company, N. Y.

KANSAS CITY
J. C. Brous, 8827 Maiden Lane, Kansas City 5, Mo. Tel: HI 8556
First Tuesday, Meeting at 7:30 P.M., U. of Kansas City, Science Bldg., Rm. 106.

LOUISVILLE
C. M. Bosworth, 5336 Westhall Ave., Louisville, Kentucky. Tel: FR 3494
First Monday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
L. E. Henne, Bristol Co. of Canada Ltd., 712 Dominion Square Bldg., Montreal, Quebec, Canada Tel: UNiversity 6-4725.
Last Monday, 8:00 P.M., Mechanic's Institute.

MUSCLE SHOALS
Atherton Hastings, Tennessee Valley Authority, Div. of Chemical Engineering, Wilson Dam, Alabama. Tel: Sheffield 3160, Ext. 6238
First Thursday, Meeting 8:00 P.M., TVA Chemical Engineering Bldg.

NEW JERSEY
L. H. Ballinger, 2371 Channing Ave., Westfield, N. J. Tel: Westfield 2-0765M
First Tuesday. Meeting at 8:00 P.M., Essex House, Newark.

NEW ORLEANS
W. H. Haney, 2927 Music St., N. O. 22, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
F. B. Leslie, 520 South 14th St., New Hyde Park, N. Y. Tel: FI-7-0645.
Last Monday, Dinner at 6:00 P.M., Meeting at 7:45 P. M., Hob Nob Club, 108 E. 41st St.

NIAGARA FRONTIER
Mrs. James L. Martin, 34 Manning Rd., Eggertsville 21, N. Y. Tel: WIndsor 0087
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., N. Y. State Inst. of Arts and Sciences, Buffalo.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHERN CALIFORNIA
Bert L. Anderson, 1951 47th Ave., San Francisco 16, Calif. Tel: SEabright 1-5030
Third Monday, Dinner 6:30 P. M., Meeting 8:00 P.M., Spengers Grotto, 1919-4th St., Berkeley.

NORTHERN INDIANA
J. Baum Beckman, 7145 Wicker Ave., Hammond, Ind. Second Tuesday, Meeting at 7:30 P.M., Whiting Community Center, Whiting, Ind.

OAK RIDGE
George Ritscher, 113 Gorgas Lane, Oak Ridge, Tenn. Tel. 5-1084
First Wednesday, Meeting at 7:30 P.M., Ridge Recreation Hall

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside. Ontario, Canada. Tel: HU-7114
Third Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

PANHANDLE
Bruno F. Loewen, Philips Chem. Co., Box 1526, Borger, Texas.
Third Tuesday, Meeting at 8:00 P.M.

PERMIAN BASIN
J. B. Jenkins, 509 South Ave. "C," Kermit, Texas. Tel: 3220
Second Tuesday, Meeting at 7:30 P. M., Gulf Oil Corp. Auditorium or Odessa College.

PHILADELPHIA
R. A. Trenner, Energy Control Co. Rm. 306, 3147 N. Broad St., Philadelphia 32, Pa. Tel: SA 2-7900
Third Wednesday, Meeting at 8:00 P.M., Bellevue-Stratford Hotel.
September 18, "Gadget Contest," Prizes to be awarded to local members.

PITTSBURGH
Dr. A. H. Peterson, Mellon Institute, 5500 Fifth Ave., Pittsburgh 13, Pa. MAflower 1-1100
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Roosevelt Hotel

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa. Tel: 2-3349
Fourth Tuesday, Meeting at 8:00 P.M., G. E. Community Center, East Lake Rd., Erie, Pa.

RICHLAND
T. H. Quinn, 1513 Goethals Dr., Richland, Wash. Tel: 7-8717
Second Wednesday, Meeting at 7:30 P.M., American Legion Hall.

ROCHESTER
R. C. Schwarz, Jr., Foxboro Co., 1201 Granite Bldg., Rochester 4, N. Y. Tel: Hamilton 1468.
Fourth Tuesday, Meeting at 8:00 P.M., Univ. of Rochester, Physics Lecture Hall.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Second Monday, 8:00 P. M., Y.M.—Y.W.C.A.

SAVANNAH RIVER
F. P. Ledford, Jr., c/o Field Project Manager Ga.,
E. I. du Pont de Nemours and Co., Box 117 Augusta, Ga.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas. Tel: 122-W
First Wednesday. Meeting at 7:30 P.M.

SOUTHERN MICHIGAN
Lyle J. Draper, 2233 Oakland Dr., Kalamazoo, Mich.
Fourth Wednesday, 8:00 P. M., Dinner at 6:30 P. M., Chicken Charlie's, Kalamazoo.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.

TOLEDO
P. H. Girkins, 418 Waggoner Blvd., Toledo 12, Ohio. Tel: LA 6505
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TENNESSEE
James L. Williams, 2237 Bruce St. Kingsport, Tenn. Tel: 2079-L
Fourth Thursday, Civic Auditorium.

TULSA
S. M. Bagwell, 1544 E. 35th Pl., Tulsa 5, Okla. Tel: 7-6822
First Monday, Meeting at 7:30 P.M., Engineering Bldg., Tulsa Univ.

TWIN CITIES
Jerome J. Schwab, Engineering Sales, 516 Guardian Bldg., St. Paul 1, Minn. Tel: GArfield 0601
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P.M., Rm. 355, Coffman Memorial Union, U. of Minn.

WASHINGTON
Edward C. Lloyd, 2105 Spencer Road, Silver Spring, Md. Tel: SH. 9340.
Third Monday, Meeting at 8:00 P.M., P. E. P. Co. Auditorium.

WAYNE COUNTY
J. R. McCauley, 18073 Archdale, Detroit 19, Mich. Tel: KE 1-5239.
Third Monday, Meeting at 8:00 P.M., Larson's Cafe, Lincoln Park, Mich.

WILMINGTON
E. Avery Taylor, Taylor Instrument Co., Industrial Trust Bldg., Rm. 510, Wilmington, Del. Tel: 9814.
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.

ISA Welcomes Two New Sections

The ISA Executive Board, upon recommendation of the Sections and Membership Committee, has voted favorably on the Charter applications of two new Sections.

The Savannah River Section located at Augusta, Georgia was granted an ISA Charter effective March 27, 1952. The Section has elected Lawrence E. Kennedy, President; T. K. Conlin, Vice-President; E. P. Ledford, Jr., Secretary; and E. L. Karlson, Treasurer; and Thomas Waldrup, Council Delegate. This Section was composed of forty charter members, of which thirty-six were new Members of ISA and 4 transferees from other Sections.

The Muscle Shoals Section, located at Wilson Dam, Alabama, was granted an ISA Charter on June 17, 1952. The officers of this newest Section of ISA are: President—F. B. McCoy, Jr.; First Vice-President—Elmer S. Hayes; Second Vice-President—E. O. Greer; Secretary—Atherton Hastings; Treasurer—C. D. Mitchell; Council Delegate—C. A. Mohler; and Alternate Delegate—R. C. Sprenger. Twenty-four members comprise the Muscle Shoals Section, of which twenty-one are new Members of ISA and 3 have transferred from other Sections.

We wish to express our appreciation to the Members of these Sections and members of the Sections and Membership Committee, who have been instrumental in bringing these Sections into being, and to extend to these Sections our heartiest good wishes for a successful future.

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA
1319 *Allegheny Ave.*,
Pittsburgh 33, *Pa.*

EXPERIENCED INSTRUMENT MEN. Two Development Engineers—college graduates with up to 5 years experience; and three high school graduates with instrument, tool or similar experience—for sales correspondence, work estimating, and sales for Philadelphia Manufacturer of pneumatic controllers and comparator gages. Box 670.

HELICOPTER INSTRUMENTATION ENGINEER. To solve instrumentation problems in wind tunnel, whirlstand, and flight testing of helicopters and convertiplanes. Desirable background—aeronautical or mechanical engineering course (including instrumentation theory) and several years industrial instrumentation experence. State training, experience, and salary requirements. Replies confidential. Box 671.

ELECTRONIC ENGINEER Western New York research organization is seeking a graduate electronics engineer who is capable of designing complicated electronic instruments for use in flight research work. For full details write to Box 672.

CHEMICAL ENGINEER to design and prescribe and procure instruments and controls for flow, temperature, etc. in semi-chemical processing plants in large industrial area. Location—Minnesota area. Salary commensurate with experience. This position is not dependent on defense orders. Box 673.

GOVERNMENT SERVICES

To apply for any of the following Federal Agency positions, write direct to the Agency holding the position for official application form.

U. S. Naval Ordnance Test Station, Inyokern, China Lake, California

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Practical Applications of Electron Diffraction

By S. P. NEWBERRY* and E. I. ALESSANDRINI**

THE Electron Diffraction Instrument is capable of chemically analyzing as little sample material as five micro-micro grams and can do this when the material is spread in layers as thin as 15 angstrom units. Within the last eight years this powerful new analytical tool has been made available to industrial laboratories in the form of commercial equipment. It is slowly but surely establishing increasing numbers of applications, many of these being impossible by any other method.

In the laboratories at General Electric increasing use for this equipment is being found and units are now operating in four different divisions of the company. Some representative case histories have been selected to illustrate what can be done with this technique. But first, a description of the equipment and how it is used will be given.

Principles of Electron Diffraction Instruments

As shown in Figure 1, the instrument contains an electron gun which forms an essentially parallel beam of electrons. This gun consists of a tungsten filament at 50 kilovolts negative and a grounded anode plate which accelerates the electrons and which has a hole in its center to let electrons pass on through. In practice, a Wehnelt cylinder is placed around the filament to force more of the electrons to pass through the anode aperture.

By means of a magnetic focusing coil, the electron beam from this gun is then made almost exactly parallel or slightly converging to form as small a spot as possible at the flouresent screen. The specimen to be studied is mounted on a manipulator which has five controlled motions, including three translations and two rotations.

If a fine powder or thin film is to be studied, it is mounted on a manipulator which has five controlled motions, including three translations and two rotations.

If a fine powder or thin film is to be studied, it is mounted on a small screen wire mesh as shown (Fig. 4). If the surface of a solid object is to be studied, it is bolted or clipped onto the manipulator with the surface to be studied essentially parallel with the direction of the beam. By using the adjustments on the manipulator the specimen is moved into the beam.

The appearance of a characteristic diffraction pattern is looked for, first on an auxiliary fluorescent screen on the back of the shutter and then on the large fluorescent screen (Fig. 1). The shutter and screen are nominally 10 and 50 cm, respectively, from the sample. For purposes of computation, the sample to plate distance is measured by a telescope and scale.

A photographic plate can be substituted for the large fluorescent screen and a permanent record obtained of the diffraction pattern. Exposure of the plate is controlled by the shutter. Because electrons are scattered and absorbed by air, the whole system including the photographic plates is contained and manipulated inside a vacuum tight enclosure.

Description of a Modern Model

A modern self-contained electron diffraction instrument is shown in Fig. 2. Dr. H. O. Spauchus, of the Pittsfield laboratory, is shown lifting the photographic plates from the screen end of the instrument. The gun end of the instrument can not be seen but is located in a high voltage enclosure behind the control panel. The large cubical specimen chamber can be seen with the controls for the specimen manipulator, visible at the top and a magnetically-controlled vacuum valve visible below.

The edge of the magnetic focusing coil can just be seen on the left side of the manipulator box. The high voltage supplies and vacuum pumps are located toward the back of the equipment. The cabinet is mounted on large casters for transportability and the only outside connection is an ordinary wall plug. The pumps are air-cooled and no water or liquid air is required. The high voltage chamber has safety interlocks to prevent accidental contact with 50 kilovolts.

A closer view of the specimen chamis given in Fig. 3 in which Dr. J. G. Hutton, of the General Engineering Laboratory, shows a large specimen which was studied in the instrument. Specimens with one dimension as large as six inches can be examined. The method for mounting powdered materials on a wire mesh is illustrated in Fig. 4.

Here a film (one-millionth of an inch thick) of plastic has been spread on the surface of a shallow dish of water by placing a drop of dilute plastic solution on the water surface and letting surface tension spread the droplet over the water. A section of this thin plastic film is then lifted on a small piece of screen wire mesh where it forms a supporting membrane for the powder sample.

Interpretation of Diffraction Patterns

The theory of electron diffraction is well described in the literature. [1, 2, 3]

* General Eng'g. Lab., and ** Research Lab., General Electric Co., Schenectady, N. Y.

Presented at the Sixth Annual Conference of the Instrument Society of America, at Houston, Texas, Sept. 10-14, 1951.

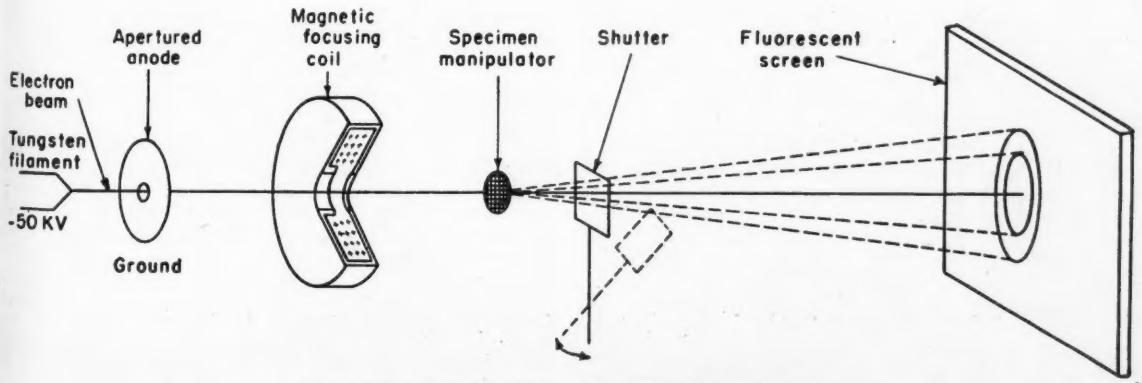

Fig. 1. Basic operation of the electron diffraction instrument

For most practical applications, however, it is sufficient to know that the diffraction effect causes a parallel beam of electrons to diverge at the specimen so as to form a pattern of concentric rings on the fluorescent screen or plate.

A set of rings from zinc oxide in a typical transmission pattern is shown in Fig. 5 while a typical reflection pattern from an oxidized steel surface is shown in Fig. 6. The reflection pattern rings cover a little less than half of a circle since the other half of the pattern is lost in the surface of the sample.

The diameters of these rings are related to the various spacings between neighboring planes of atoms in the specimen by the familiar Bragg formula:

$$n\lambda = 2d \sin\theta$$

where the wave length of the electrons, λ is:

$\lambda = 12.33$ divided by the square root of V.

or for 50 kv electrons, $\lambda = 0.55$A

where $\sin\theta$ equals approximately:

$$\frac{\text{specimen to film distance}}{\text{half of ring diameter}}$$

n is the order number of the ring and d is the atomic spacing one calculates.

These d value sets are never the same for any two different substances and are appropriately referred to as the fingerprint of the molecule since they are used to identify substances by reference to published data [4].

Additional Data Given by Patterns

Diffraction patterns give additional information about a specimen besides its chemical identity. If the lines are uniform as though drawn by a ruling pen, then it is known that the crystals in the specimen are very small; in fact too small to be seen in a light microscope. If the circles appear to be formed by spatter painting, then the specimen is composed of larger crystals.

In Fig. 5 many individual crystals are evident, some as long as several microns. The crystal size is often important and many times it not what it appears to be under the microscope. A case history concerning crystal size is given below.

If the circles tend to disappear in some quadrants and show greater exposure in the opposite quadrants, then there must be something about the specimen tending to line the crystals up in one directoon; this is called *preferred orientation.* One of the first practical applications of electron diffraction was the discovery that a good lubricant orients itself with the long axis of its molecules perpendicular to the lubricated surface while a poor lubricant does not.

If the diffraction circles are broader in some quadrants without disappearing in the other quadrants, then the surface is under stress in the direction of the broadened quadrants. At a point of surface stress, corrosion is likely to occur.

There is more information which may be obtained from the appearance of the diffraction diagram. For example, the simple information that the surface is crystalline or amorphous may be of great value. Of equal value may be the knowledge that the surface layer is conducting or non-conducting.

Comparison with X-ray Diffraction

For those readers who are familiar with X-ray diffraction, it is very helpful to compare the two diffraction techniques. In basic action, they are identical and the same d values are obtained by both methods. The penetration power of 50-kilovolt electrons is small, not exceeding 1000 A° units. The same voltage X-rays can penetrate a millimeter or more. Electrons therefore given information about the surface while X-rays give information about an average of the entire sample.

Electrons can dectect samples as thin as 15 A° units and can detect a minor constituent present to only ½ per cent as compared with 5 per cent for X-rays under the same conditions. The specimen does not need to be evacuated for X-ray but must be evacuated for election diffraction. The time lost in pumping, however, is more than compensated by the difference in exposure time because average exposures for X-rays are one to ten hours compared with from five seconds to two minutes for electrons.

Modern Geiger-counter X-ray units are faster, though less informative, than the photographic X-ray units. Electrons have the further advantage that the pattern can usually be seen visually before photographing and in routine control work may not need to be photographed at all.

The electron voltages, which are practical for diffraction, give wave lengths about 1/20 of the wave length used for X-ray diffraction. For this reason, electrons are diffracted by shorter spacings than X-rays and give crystal size estimates for a smaller size range than the X-ray unit gives. The electron diffraction unit is not plagued with the troubles of finding the right tube and filter combination because the electron beam is much easier to collimate and reduce in size than the X-ray beam. It is highly monochromatic, thus giving sharper patterns. The total installation cost for the two diffraction methods is about the same.

To summarize, X-ray and electron faces which gave good secondary diffraction operate on the same principle, and are complementary rather than redundant techniques covering a wider field of application together than either alone. It seems quite reasonable to expect that in the coming years, Electron Diffraction will become as widely applied to industrial problems as X-ray diffraction now is.

Case Histories of Electron Diffraction Applications

An interesting practical application encountered recently is the case of magnesium oxide secondary emission some difference between those sursurfaces which failed to work without apparent reason. In an effort to find emission and those which did not, an electron diffraction pattern was taken of each surface. It was thought that perhaps some crystalline change had taken place on the surface which electron diffraction might detect.

When the pictures were developed and the data calculated, it was found that the bad surfaces contained a trace of copper contamination as shown in Fig. 7. The presence of copper was unexpected. However, once pointed out as a suspect, it was easily proven to be the culprit and the source of contamination was found to be copper vapor condensing on the surface from a spot-welding operation. This was easily corrected by depositing the magnesium coating after the spot welding operation.

A more difficult diffraction application was encountered in connection with silver relay contacts. In this case history, the contamination was known to be silver sulfide but the puzzle was its source. The problem could be confined to the silver contacts prior to assembly on the relay. The most likely place to look was to the packaging material in which the contacts were shipped and stored for some time.

Chemical analysis showed sulfur present in both the wrapping and the plastic box, but to no greater extent than in previous packaging before trouble was encountered. Clearly, what was needed was not analysis of sulfur in the packaging materials but proof that sulfur was being transferred from one of these materials to the siver and under what conditions, such as temperature, humidity, etc., it was being transferred.

The direct approach of storing contacts with each component operating under different conditions and watching for formation of the black sulfide tarnish was hopeless because conditions which might take weeks or months to give visible corrosion needed to be detected. With Electron Diffraction as shown in Figs. 8 and 9, the onset of sulfur corrosion could be detected after overnight exposure so it now became an easy matter to apply the direct approach.

It was soon learned that the plastic boxes were the source of the trouble but not all boxes. Only those boxes which were put together with self-tapping screws caused trouble and not those fastened with machine screws. It was subsequently learned that not the self tapping screws themselves, but the plastic shavings cut out by the self threading operation was the cause of the trouble. Why the shavings should offend was never de-

Fig. 2. Dr. Spauschus and his G.E. diffraction instrument.

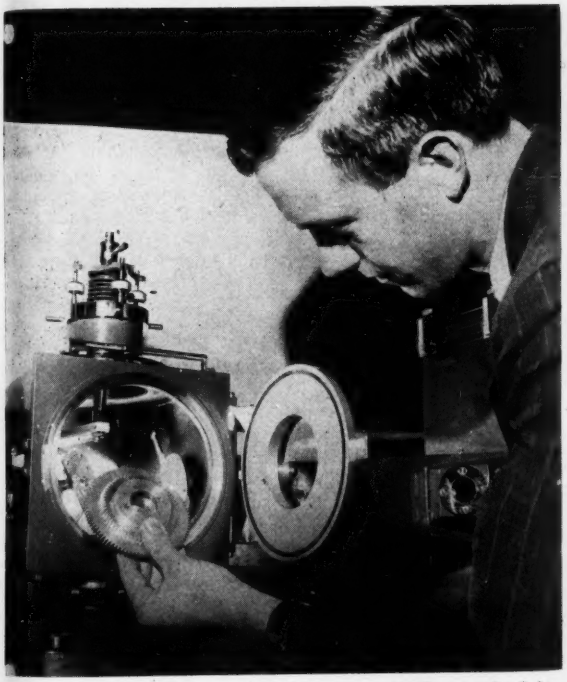

Fig. 3. Dr. J. G. Hutton and a large gear sample examined in the electron diffraction instrument.

Fig. 4. Floating a supporting film onto a screen in the preparation of a powder sample.

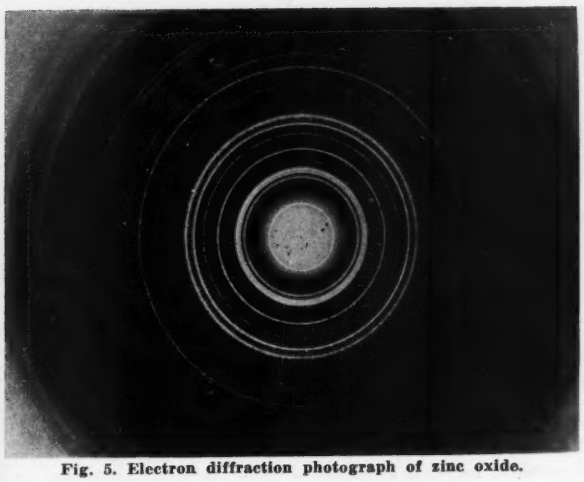

Fig. 5. Electron diffraction photograph of zinc oxide.

Fig. 6. Oxidation on a silicon steel sample.

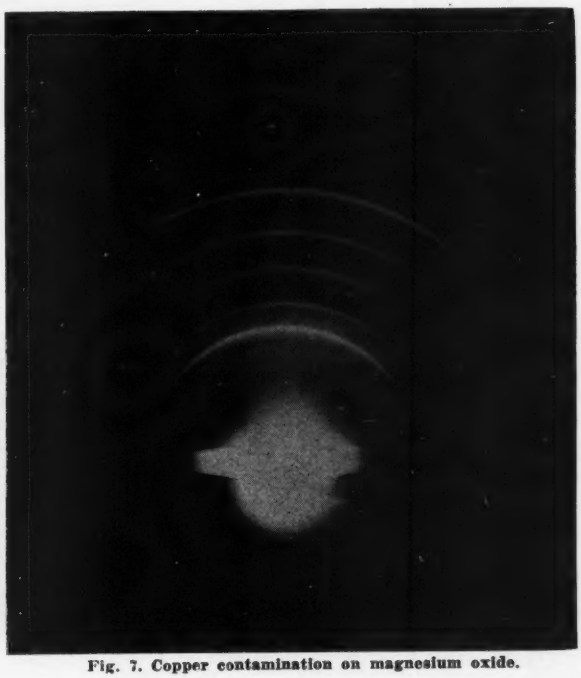

Fig. 7. Copper contamination on magnesium oxide.

Fig. 8. Detection of sulfide on silver contacts; bare silver.

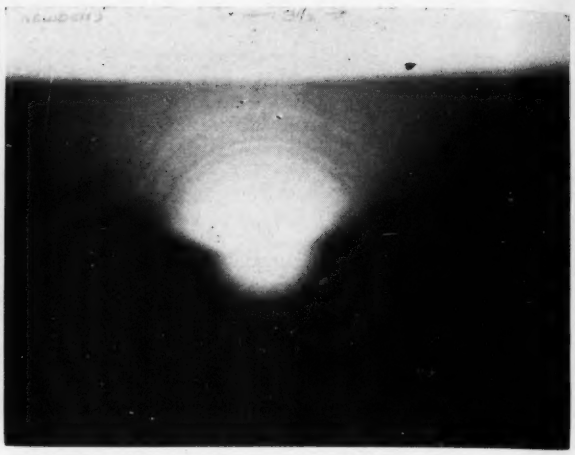

Fig. 9. Detection of sulfur on silver contacts; showing sulfide; note changes from Fig. 8.

termined, but the self-threading screws were abandoned and the trouble disappeared.

Other Corrosion Applications

The above story illustrates one of the more simple cases of corrosion in which one could compare the base metal (a noble metal) against the corrosion product. In a study of corrosion on lead cables, a comparison picture was taken of a clean lead surface first, but only lead oxide was found.

It was found to be impossible to cut a clean surface on lead and introduce it into the vacuum quickly enough to get anything but the oxide to show (even though the exposure to air was reduced to a few seconds.) The new surface would have to be cut by a knife mounted inside the vacuum to obtain a lead pattern. Fortunately, the corrosion turned out to be lead carbonate and was easily distinguished from the lead oxide.

With metals such as the steel sample of Fig. 6, the situation is even more complex but by no means hopeless. On the surface of an uncorroded steel one finds every conceivable oxide of iron plus metallic iron and alloying constituents. However, the unsaturated oxides such as FeO predominate while, as corrosion proceeds, the bare metal disappears and the unsaturated oxide disappears in favor of the more saturated oxide. Finally, in advanced corrosion (still invisible to the eye), the surface is chiefly covered with Fe_2O_3 and Fe_3O_4.

A further experimental difficulty comes from the limitation imposed upon the surface contour and roughness of the sample by the reflection techniques. The surfaces must be reasonably flat or convex for about five millimeters and should not be a rough casting or rough machine surface. Often, a small spot can be especially prepared at a test area before the test is run.

Study of Germanium Crystals

Another interesting problem was found in a difficulty with germanium crystals. Some crystals with carefully polished faces didn't behave like germanium at all. Electron diffraction showed the presence on the surface of magnesium oxide, the last polishing agent used. Even more important, diffraction showed that vigorous cleansing action is necessary to remove magnesium oxide. The problem was solved by obtaining a new material for the final polish.

The germanium group presented another interesting problem: the determination of the crystal habit of a thin evaporated layer of germanium. This element is known to transform to a new crystal arrangement if its temperature is raised to about 350° C. The question was: did the thin films which had been formed by condensation of the hot vapor have the normal or transformed crystal habit? The films were too thin for X-ray diffraction analysis but too thick for the electron microscope and the crystals too small for the light microscope.

Electron diffraction proved that the film was of the normal form but the fuzziness of the rings shown in Fig. 10 tells that the crystals were only approximately 15 A° in diameter or less. An electric furnace was then built inside the specimen chamber so that the film could be observed as it

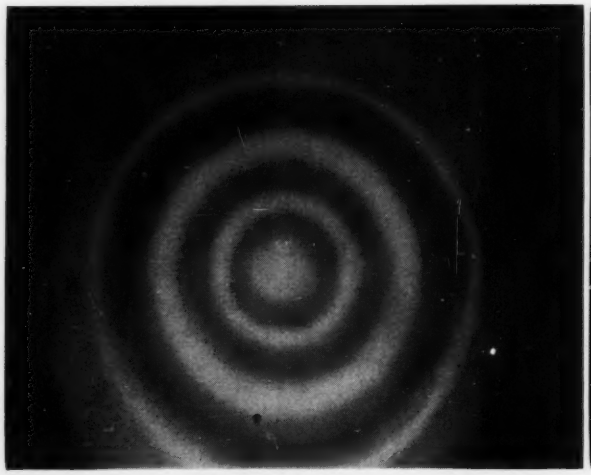

Fig. 10. Electron diffraction photograph of sample of germanium film showing lack of crystalinity.

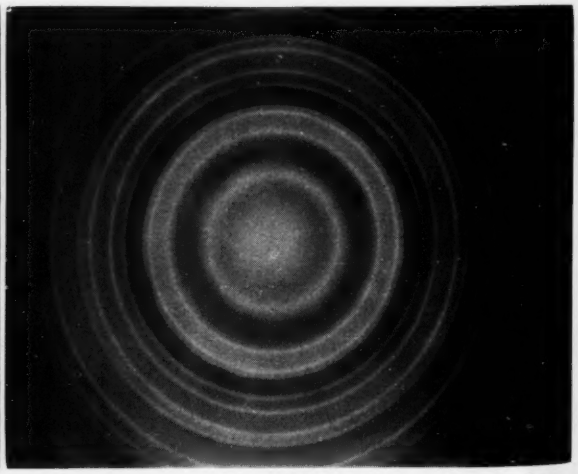

Fig. 11. Germanium film recrystallized in the instrument above 350° C.

was gradually heated. A transformation was found at approximately 350° C just as with the bulk material. This is shown by Fig. 11 which is the same sample after heating to 350° C. Recrystallization to larger crystals has occurred.

Rectifier Problems and Checking of Leak Detector Poisoning

Rectifier materials are ideally suited for study by Electron Diffraction because the rectifier action is dominated by the surface layers. In our laboratories, problems have been solved not only with germanium but also with copper oxide and selenium rectifiers, and interesting work is now underway on problems connected with tantalum electrolytic capacitors.

The Type H Leak Detector is familiar to many of our readers. It works upon the principle that positive ion emission from a platinum surface is increased by the presence of a halogen vapor such as methyl chloride. After prolonged use, some of the detectors appeared to become permanently poisoned.

Electron diffraction did not show the presence of a covering film or corrosion but instead indicated an increase in the crystal size of the platinum with prolonged use. This was shown to be the cause of reduced ion emission. The difficulty was overcome by running the unit at a slightly lower temperature. It is important to note here that no microscope could show this change because the crystal size of the platinum is much less than the grain size of the metal, which is what one observes microscopically.

Determining Unknown Phase In Alloy

There is a story of an alloy which was very difficult to machine and lead to short tool life. The metallograph easily told what was wrong because samples taken from poor machine stock disclosed an unknown phase in the grain boundaries which was presumably harder than the alloy and responsible for the excessive tool wear. Unfortunately, there was more than one alloying constituent present which, if segregated, might cause this kind of trouble.

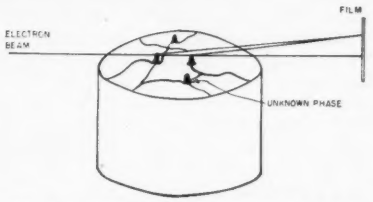

Fig. 12. Determining an unknown minor phase by electron diffraction.

The further possibility existed of accidental inclusion of foreign material, so it became important to find out what the unknown phase was. This looked like a problem for X-ray analysis because the minor unknown phase to be detected was not on the surface but down in the body of the material. X-ray analysis can not detect material present in less than about 5 per cent concentration, however, and failed to identify this unknown material.

Electron Diffraction can detect as little as ½ per cent so a method was sought for applying Electron Diffraction to this problem. A rather ingenious method was devised as shown in Fig. 12. An etching agent was discovered which would not dissolve the unknown phase and thus, when applied to the surface of a standard metallurgical preparation, left the unknown standing above the surface in bold relief. Fig. 12 shows how the specimen was placed in the beam to get essentially a transmission pattern which was predominately from the unknown.

The specimen is shown highly magnified in the diagram to illustrate the principle, while the electron paths and photographic film are shown on reduced scale to get them in the picture. This technique should prove to be very useful for other problems of determining a minor phase in an alloy. In the present instance, titanium oxide proved to be the cause of the machining trouble.

Checking Catalyst Consumption

Study of surface changes in a catalyst is an illustration of the power of the electron diffraction technique. Such

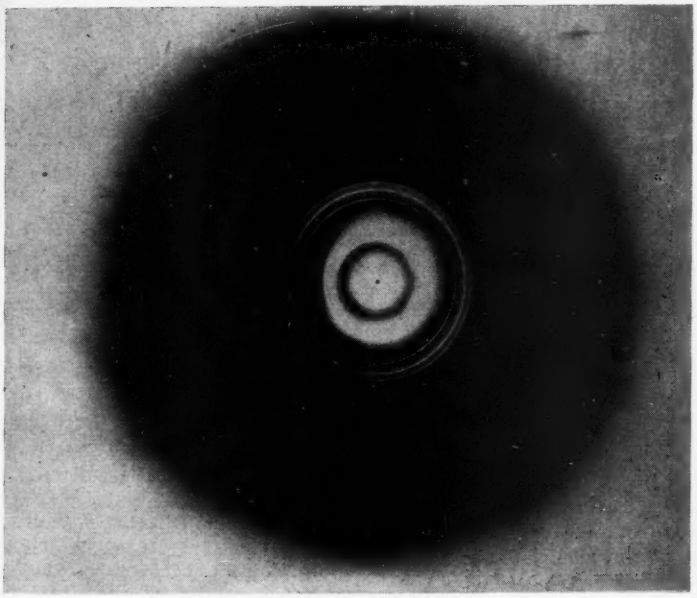

Fig. 13. Unused catalyst

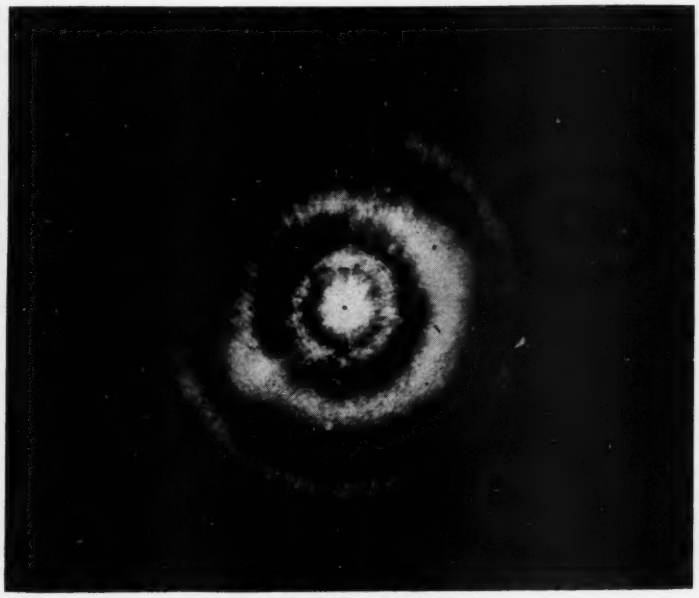

Fig. 14. Partly used catalyst.

changes are shown in the series of photographs (Figs. 13 to 15 inclusive). In this particular problem, the surface becomes coated with a thin layer of amorphous material. When all the surface is covered, the catalyst became ineffective.

This suggests a possible control application to check when the catalyst should be renewed. A further possibility is to determine the conditions which affect the rate of contamination of the catalytic surface with a great saving in testing time, because changes in the catalyst surface are apparent to the diffraction instrument before they have progressed far enough to affect noticeably the efficiency of the catalyst.

The Vacuum Tube Department at G-E frequently calls on the Electron Diffraction Laboratory for help. On one occasion, they had a discoloration in some tubes which occurred from time to time for no particular reason. The discoloration occurred during the seal off operation and was suspected of being something from the glass or glass surface.

It was proven by electron diffraction to be aluminum oxide which is not expected to be present in the glass but which was present in the "getter" mixture. It was found that in the presence of water vapor sufficient heat is developed during seal off to cause the formation of this discoloring film of aluminum oxide.

Some Other Applications

The instrument was once used to solve one of its own problems. In some of the instruments during the first test after assembly, the electron gun became covered with a black and grey coating which distorted the electron beam and caused voltage breakdown. Repeated cleaning of the gun and retest proved that an almost inexhaustable supply of the coating material was present.

An Electron Diffraction picture of scraping from the discolored area (which included almost all of the gun and insulator areas) showed the presence of fluorides used in the brazing flux. These were found to be hiding in inperceptible recesses in brazed joints which were impossible to clean by surface treatment. The difficulty was overcome by vacuum firing the parts before assembly.

Beside those illustrated, there are many more fields . . . for which the Electron Diffraction technique might be useful but it has been available for industrial application for such a short time that most of these have not been tried. The following example is offered as an illustration of what might be done in the deep-drawing field.

It is known that surface layers on a metal greatly affect the friction encountered in deep-drawing and that some corrosion products actually lubricate as compared with a clean metal surface. The electron diffraction equipment may possibly be used as a research tool to tell what corrosion products are responsible for good and bad drawing lubrication and perhaps can be used as a routine production test to make sure that the proper surface materials are present before trying to use the metal in the punch presses.

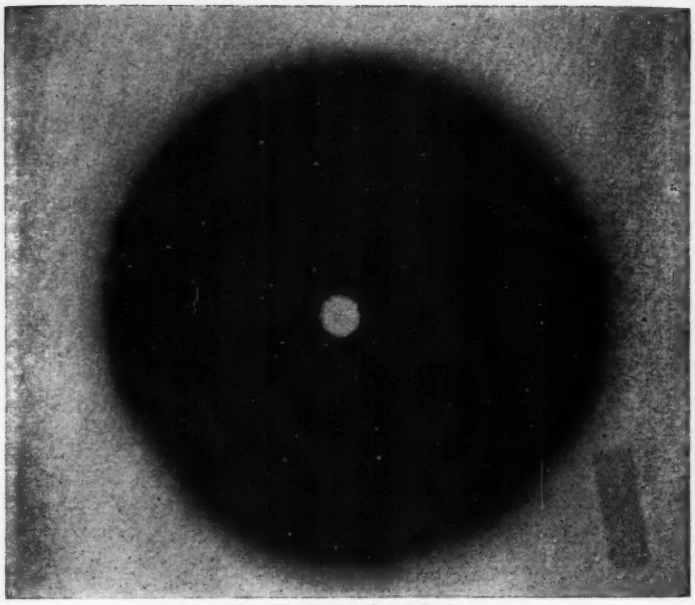

Fig. 15. Depleted catalyst.

Summary

The electron diffraction instrument has been described, and the interpretation of electron diffraction patterns outlined. This paper has also presented a number of uses of the instrument as an aid in the solution of practical problems.

Most of the applications described were encountered in connection with electrical manufacturing, but similar types of problems must be common in all laboratories. It is expected that much wider use will be made of electron diffraction techniques in the years to come.

Acknowledgement

The authors appreciate the assistance of Mr. M. J. Columbe and others for operation of the equipment and calculations of the patterns. They also wish to thank Dr. G. W. Dunlap and Mr. R. M. Ilfeld for reviewing the manuscript.

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Fig. 1. Gas-control station, showing 8-inch regulator and adjacent 20-inch header, which were the principal sources of noise.

Gas Regulation and Noise Control

By F. M. PARTRIDGE
Southern California Gas Co.

Noise problems exist at both new and old, above-ground and under-ground, gas-regulating stations. Electric-motor-operated valves are used in one new installation.

LAST year the writer presented a paper "Noise Problems at Regulator Stations" (see *Instruments*, Nov. 1951, pages 1361-1364). This article is a continuation of that work.

Noise was defined as any disturbing sound. Sound level usually is measured in logarithmic units called decibels on a scale ranging from the sound of rustling leaves at 20 decibels to an airplane-motor test chamber at 140 decibels.

Regulator in Underground Concrete Vault

The usual practice for reducing noise at regulator stations in underground vaults has been to provide insulation on the vault cover to keep the sound from leaving the vault. This has been effective to some extent but does not improve conditions for those who must enter the vault or for persons in the vicinity when the vault covers are open. To improve this condition and to test the effectiveness of "Fiberglas" sound insulation, which had been recommended for the purpose, a test was conducted at an underground regulator station. This station consisted of an 8-inch balanced valve regulator and two plug-valves in a reinforced concrete vault with full opening covers.

The vault covers were removed and the sound-level-meter microphone was set up at the edge of the vault. When gas was passed through the regulator, the sound level was 101 decibels. The gas then was shut off and the piping, valves, and regulator were wrapped with "Fiberglas" building insulation to a thickness of about two inches. The regulator was put back into operation and the sound level was found to be only 80 decibels.

TEST DATA

	Before Insulation	*After Insulation*
Flow rate, mcf/hr.	4630	4000
Upstream pressure, psi.	390	400
Downstream pressure, psi.	133	133
Sound level, decibels	101	80

It was felt that this was a worthwhile sound reduction for a temporary installation but that better results could be attained by using a heavier type of insulation around the fittings, and that sound insulation on the walls of the vault would be helpful in absorbing unwanted noise.

The Southern Counties Gas Company applied "Fiberglas" insulation as a permanent installation on a similar vault. Insulated boxes, which were removable, were installed to enclose the regulators. This insulation reduced the sound level at the edge of the open vault from 95 decibels to 58 decibels. When the steel covers, which had been sprayed on the underside with automobile undercoating, were closed the sound level dropped to about 50 decibels.

No tests were conducted to indicate the relative effectiveness of different kinds of sound insulation. "Fiberglas" was recommended and used for the test and the results obtained were satisfactory. Other insulation may be as good or better.

Above-ground Control Station

In recent years there has been a tendency to install large measurement and control stations underground to improve appearance and to minimize noise complaints. However, the problem of eliminating objectionable noise levels at existing above-ground stations must be met from time to time.

A recent example involved a measurement and regulation installation at a large holder station. (See Fig. 1.) Gas at a pressure of about 200 psi. passed from the near header through the 8-inch regulator in the center and was reduced to 100 pounds pressure in the adjacent 20-inch header. The gas leaving the regulator at high velocity and entering the right 20-inch header created a sound level of about 100 decibels.

Several plans were considered for reducing noise. These included the construction of various walls and buildings and the absorption of the sound by various materials. The placing of the installation underground also was considered. As all these plans were costly, it was decided to place "Fiberglas" insulation around the principal sound sources.

It was difficult to locate the chief noise sources in the piping by sound-level meter. It appeared reasonable that the greatest sound would come from the piping surface with the most intense vibration. A test was conducted at an isolated station to find out how the piping vibration varied upstream and downstream from a regulator and also to see the effect of flanges, valves, and fittings on the piping vibrations. Fig. 2

Presented at the June 19, 1952 meeting of the Southern California Meter Association.

shows the station piping with the vibration at several points graphically indicated in units of acceleration in inches per second per second. The regulator was relatively free from vibration, but there was a sharp peak in the vibration curve at the spool downstream from the regulator. The plug valve downstream from the spool also was subject to less vibration. From here the gas entered a large cross header where the most intense vibrations on the installation were observed, apparently due to the blast of high-velocity gas into the header. A high vibration level was observed on the pipe where the gas left the header, but this was largely dampened out by an adjacent plug valve. The reason for the valve acting as a damper on the pipe vibration was probably due to the discontinuity of the pipe at the flange and to the relatively large mass of the valve body.

Inspection of the vibration-intensity curve led to the arbitrary decision that sound insulation should be applied on those portions of the piping where the vibration acceleration exceeded 300 inches per second per second.

A similar test was conducted at the station where the noise problem was being investigated (Fig. 3). A decision was made to apply sound insulation to the pipe and fittings where the vibration acceleration exceeded 300 inches per second per second. The insulation consisted of approximately 3 inches of "Fiberglas" with a weathercover for protection and appearance. Before insulating the piping the sound level at the nearest station property line was 79 decibels with the station under normal operation. This was 27 decibels above the minimum background noise level of 52 decibels. It had been planned to include sound-level data and pictures of the completed insulation job as part of this article, but due to delays caused by storms this was not possible.

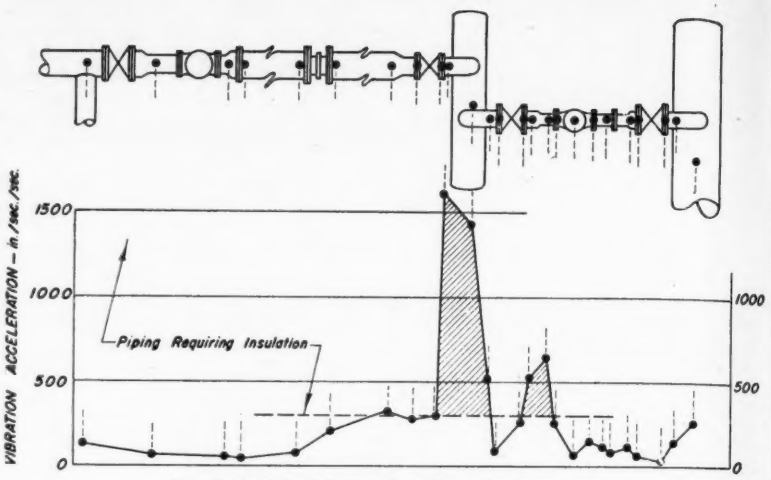


Fig. 2. Method of determining principal noise sources.

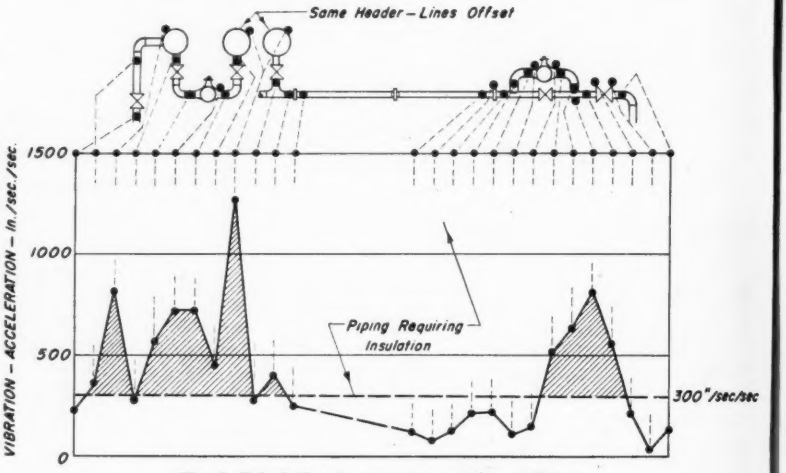


Fig. 3. Principal noise sources at station of Fig. 1.

New Measurement and Control Station

In the design of a large measurement and control station at one of the terminals of the 30-inch Texas Line it was necessary to provide a low sound level because of neighboring business establishments (Fig. 4). Thus the station was designed and built underground. A concrete vault was installed around the orifice-meter fittings. Pressure is regulated by buried 16-inch plug valves with extended gearing and electric motors. Measurement is obtained through one 8-inch primary meter and two 20-inch secondary meters. The secondary-meter tubes are controlled by buried plug valves actuated by cylinders on extensions above ground.

The noise level when the station was put into operation was satisfactory. The sound-insulated covers on the orifice-meter vault eliminated the small amount of noise from that source and at the property line noise from the station was not audible even with 11 million cubic feet of gas per hour being reduced from 410 to 275 psi. pressure.

Fig. 4. New underground gas-control station.

Electric Valve-control

One of the two electric-motor valve actuators on a buried 16-inch plug valve is shown in Fig. 5. This unit has a proportioning resistor positioned by the valve plug and open and close limit switches in addition to the electric motor and gearing. The heart of the electronic controls for positioning the valve is the electronic proportional relay shown in Fig. 6. One of these relays is used for each valve controlled. The controls shown on the relay are a Manual-Auto Switch for switching between manual and automatic control, a Manual Control knob for manual control of the valve, and two indicating lights which indicate when the valve is opening or closing.

The principle of operation of the electric-motor-powered plug valve is illustrated in Fig. 7. Two proportioning

resistors with sliders are used; one slider is positioned by the valve plug and the other by the pressure controller. With a voltage impressed on the circuit as shown, it is possible to position the sliders so that no current flows through the galvanometer. Whenever one slider is moved, current flows in one direction or the other. In order to bring the current back to zero the other slider must be moved a proportionate amount. This is simply a Wheatstone-bridge method of comparing two voltages. When the controller calls for a change in valve position, some means must be provided for moving the valve in the proper direction and the right amount.

Fig. 8 shows the equipment used to control the motorized plug valve. The 0 to 17 psi. output from the conventional pneumatic pressure controller is connected to a "Pressuretrol," which consists of a proportioning resistor actuated by a bellows connected to the pressure-controller output. This proportioning resistor and a similar one connected to the stem of the motorized plug valve are connected to the electronic proportional relay. For the ½-hp. motor, it was necessary to use a reversing starter connected to the electronic relay. The limit switches and the electric motor operate the valve.

The electronic proportional relay operates from the "Pressuretrol" to vary the position of the motorized valve in proportion to the deviation of the pressure from the set point. The relay circuit impresses voltages on both the "Pressuretrol" and the valve proportioning resistor, and an amplifier detects any difference in voltage between the movable contacts of the two resistors. As the movable contact of the "Pressuretrol" resistor follows the variations of the pressure from the set point, and the movable contact of the valve resistor is positioned in direct relation to the position of the valve plug, any motion of the "Pressuretrol" or valve changes the voltage across the input to the amplifier.

There is no voltage difference between the two contact arms on the relay when the pressure is at the set point. However, if the pressure controller senses a change in pressure, the controller output pressure moves the contact arm on the "Pressuretrol," thus causing a voltage difference between the two contact arms. This voltage is detected by the electronic relay, which then closes or opens the valve as required. As the valve moves, the contact arm on the positioning resistor moves to reduce the voltage difference to zero. The relay repositions the valve until the pressure returns to the set point and the voltage difference is again zero.

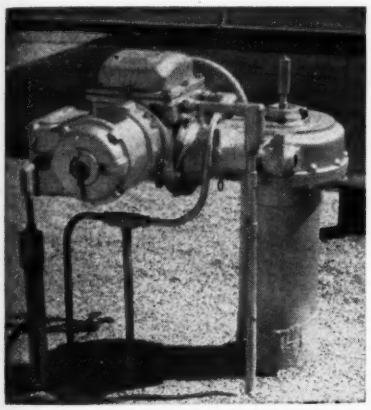
Deviations from the set point are so small, and the valve responds so quickly, that no pressure variation is discernible under normal transmission load conditions.

Conclusion

The elimination of objectionable noise in regulator stations is of great importance in improving public relations, which will in turn be beneficial to the industry when it becomes necessary to install additional gas-control stations, perhaps in residential areas.

The use of a motorized plug valve as a regulator is probably limited in application to those transmission stations where there are no rapid changes in load. However, the electric-motor-operated valves described will move from a fully open position to a closed position in approximately three minutes.

By using a pneumatic valve positioner and proportional four-way valve, this same type of pressure regulation should be possible with air motors using gas pressure to position the plug valve through proper gearing.



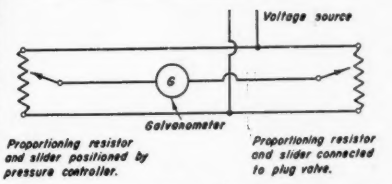

Voltage source
G
Galvanometer
Proportioning resistor and slider positioned by pressure controller.
Proportioning resistor and slider connected to plug valve.

Fig. 5. (left). Electric motor operator on buried plug valves. Fig. 6. (top right). Electronic proportional relay. Fig. 7. (bottom right). Principle of electric valve-control.

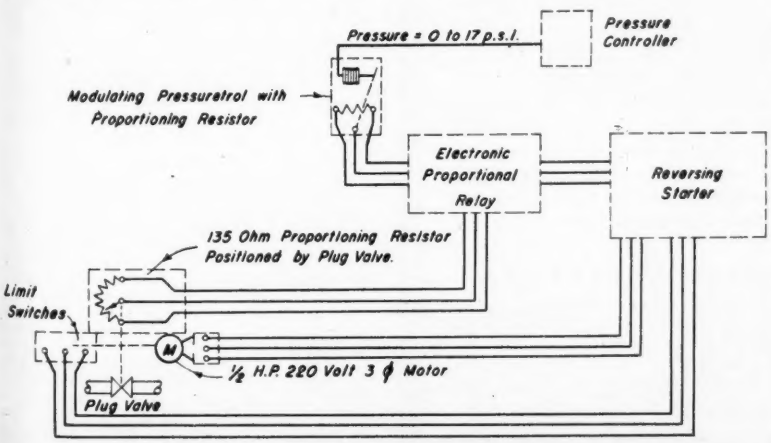


Fig. 8. Equipment for controlling electric-motor-positioned plug valve.

SCMA Elects 1952-1953 Officers

At the June, 1952 meeting of the Southern California Meter Association the following men were elected to serve for the fiscal year July 1, 1952 to June 30, 1953:

Officers

President: F. M. Partridge, Southern California Gas Co.

Vice-President: James A. Serey, Jr., Southwest Exploration Co.

Secretary-Treasurer: Geo. H. Forster, Jr., The Texas Company

Auditor: C. B. McKinney, Southern Counties Gas Co.

Past President: H. C. Bennett, Southern California Edison Co.

Chairmen of Committees

Program: Glen C. Wilson, Southern California Gas Co.

Entertainment: Frank W. Atkinson, American Meter Co., Inc.

Membership: William Richard Henry, Daniel Orifice Fitting Co.

Publicity: Bruno F. Bonhardt, Southern California Gas Co.

Standards: G. G. Gallagher, The Fluor Corporation, Ltd.

By Laws: Philip Ver Plank, Jr., Pacific Lighting Gas Supply Co.

Instrumentation: Edward A. Reps, Southern Counties Gas Co.

Directors

Robert D. Pomeroy, Southern California Gas Co.

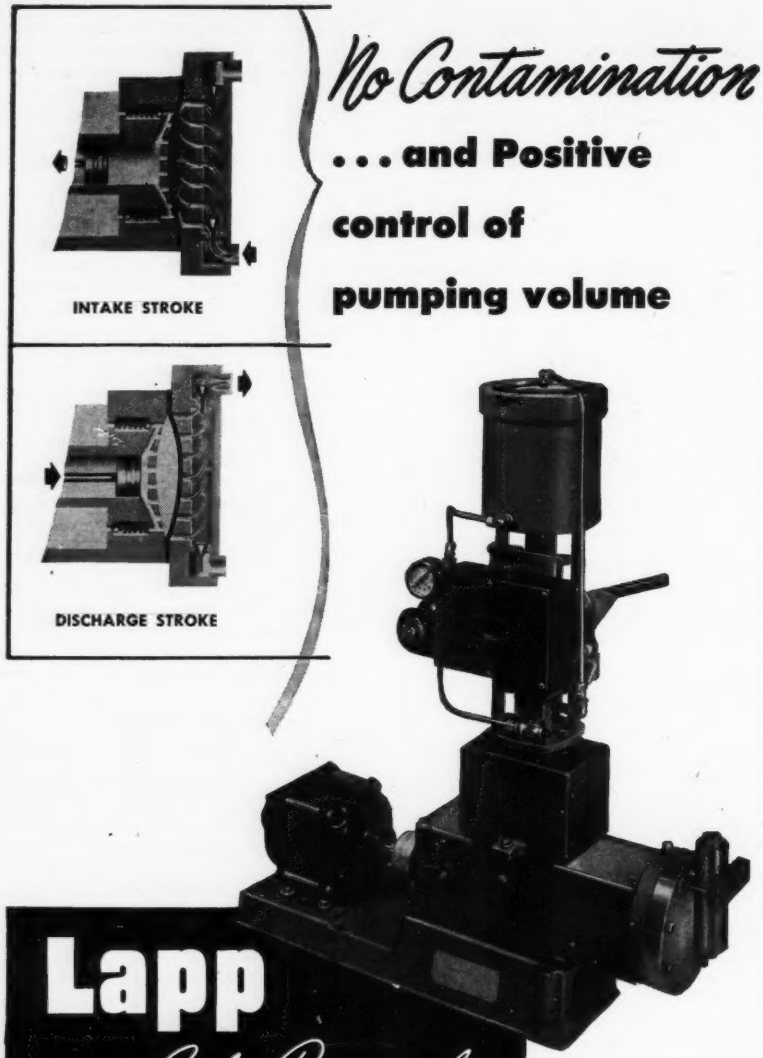
F. A. Miller, City Long Beach Gas Dept.

A. I. Thompson, Barton Instrument Co.

Walter Warneke, C. C. M. O. Co.

Hayden G. Lane, Gen. Petroleum Corp.

James E. Adams, Signal Oil & Gas Co.



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ELECTRONIC RECORDERS

Continued from page 902

In testing the remainder of the instrument the first unit to be eliminated is the measuring circuit. The thermocouple input is shorted and the amplifier input leads disconnected. A portable potentiometer is attached to the output of the measuring circuit and the potential at the top and bottom ends of the recorder scale determined. The algebraic difference should equal the span of the recorder.

The balance motor may be checked by connecting an a-c. voltmeter across the amplifier output (the red and green leads) and a portable potentiometer to the amplifier input. The input potential should be set to give the minimum output voltage from the amplifier and this should be noted (40 to 60 volts). A small signal increase from the portable potentiometer should increase the output voltage of the amplifier by from 7 to 15 volts and the balance motor should start to rotate. Reversing the red and green connections to the motor should cause it to rotate in the opposite direction. If this test fails and the 15-volt increase does not cause the motor to rotate, the motor should be repaired or replaced.

The amplifier is also checked by this procedure. If there is no increase in output voltage with a signal applied, the amplifier should be checked.

Mr. Rogers, The Foxboro Company

Foxboro uses capacity rather than resistance balance in the input circuits of their instruments. This eliminates problems associated with slidewires.

The Foxboro AC Bridge recorder is used with temperature resistance bulbs and strain-gage and variable-reluctance transducers. Part of the input circuit is assembled in plug-in boxes to provide for range change.

The rest of the input circuit consists of the Balance Capacitor, Zero Capacitor, and associated trimmer capacitors. These are assembled in the "Dynapoise Drive" unit along with solenoids and a damping dashpot. The latter make up the "balance motor" of the "Dynalog."

The third major component of the instrument is the amplifier with its associated vacuum tubes. These are the major source of trouble in the recorder.

A second difficulty, phase balance, arises when the recorder is used in conjunction with very sensitive pickup devices such as strain-gage load cells and variable-reluctance pressure pickups.

The d-c. millivolt version of the "Dynalog" has a substantially different circuit from the a-c. bridge instrument. In common with other recorders of this type the "EMF Dynalog has a vibrator. Unlike other types of recorders the Foxboro vibrator has more than two contacts. Both the signal from the thermocouple and the standard cell is switched from one to another of two circuits. This vibrator is one of the main sources of trouble. A defective vibrator may cause either pipping or sluggishness of the pen action. Another cause of sluggish action is defective tubes. Often these two sources of trouble may be confused and the vibrator replaced when a defective tube is the actual culprit. This is due to slightly better action of the new vibrator covering up for a weak tube. Therefore, even if replacing the vibrator seems to cure the troubles, the tubes should be checked to eliminate the possibility of placing the blame on the wrong component.

Complete sets of Technical Instructions which give a troubleshooting outline are available on request from the Foxboro Company. By following these closely any troubles should be readily located.

Mr. Gowen, Leeds & Northrup

The Leeds and Northrup "Speedomax G" is available in several forms. The most common has an input impedance of 7500 ohms and covers a full scale span of 2.5 millivolts or higher. A modification of this unit has a low-level measuring circuit and is used for ranges of 2 millivolts down to 200 microvolts. A third version of the recorder is the high input-impedance unit (above 8000 ohms) which may have a wide or narrow span (2-900 mv.). The external circuit of this recorder can look into a pickup which has an impedance of up to 1000 megohms. This is used in special applications such as pH recording.

In trouble shooting a recorder it is best to note whether the instrument is "dead" or only insensitive. The components should be checked individually to isolate the troubles to a particular

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unit. For specific details the instruction book for the instrument should be consulted.

Mr. Peckham, Bistol Company

Bristol has practically eliminated troubles arising from faulty vibrators. In the "Dynamaster" recorders an improved vibrator unit is employed which has a non-resonant reed that is driven with a force from 200 to 400 *g*'s at a frequency of up to 2500 cycles per second. It eliminates the need for filter capacitors in the input circuit and also provides a rugged chopping unit. Further details of the design and action of this vibrator are covered in AIEE Paper No. 51-344.

Questions to the Panel

Ques: What work has been done toward design of an instrument which would take an unknown voltage to the pen drive mechanism in such a manner that routine maintenance of slidewires, and batteries, etc. could be eliminated?

Ans: Mr. Peckham: Bristol has improved the converter and used overdesigned components in their amplifier.

Ans: Mr. Rogers: Foxboro has substituted an air capacitor for the slidewire and eliminated the 1.5 volt battery for D.C. supply to the measuring bridge.

Ques. to Mr. Gowan: Why do the thermocouples supplied with "Micromax" recorders have a twist in the end while those with the "Speedomax G," are a butt weld?

Ans. Mr. Gowen: The "Speedomax," being a high-input-impedance instrument, measures the temperature at the last point of contact of the thermocouple wires regardless of the resistance. The "Micromax" operates from the low-resistance weld at the end of the twisted pair.

Ques: Why use a three-wire resistance-bulb system rather than a thermocouple when measuring temperature?

Ans. Mr. Gowen: The resistance bulb is a high-accuracy standby and will give accuracies to 0.1 to 0.2 degrees F. for temperatures up to 1000 deg. F. Thermocouples can be used up to 3000 deg. F. but they may be off as much as 5 deg. F. at 500 deg. F and more at higher temperatures. They are all right in processes where repeatability rather than absolute accuracy is essential.

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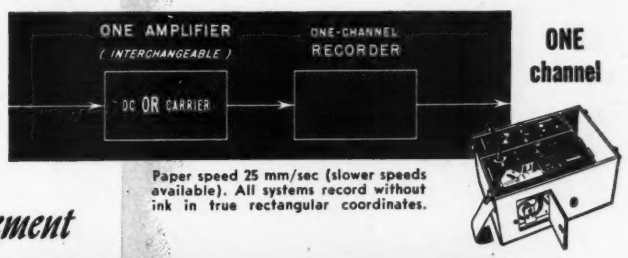

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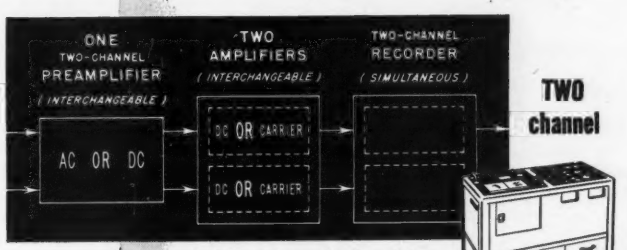

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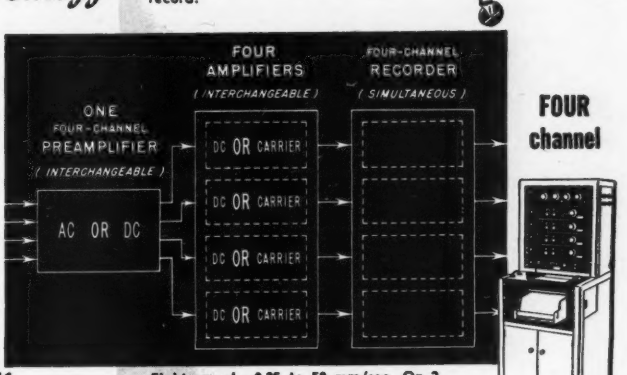

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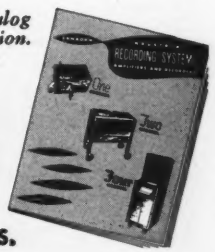

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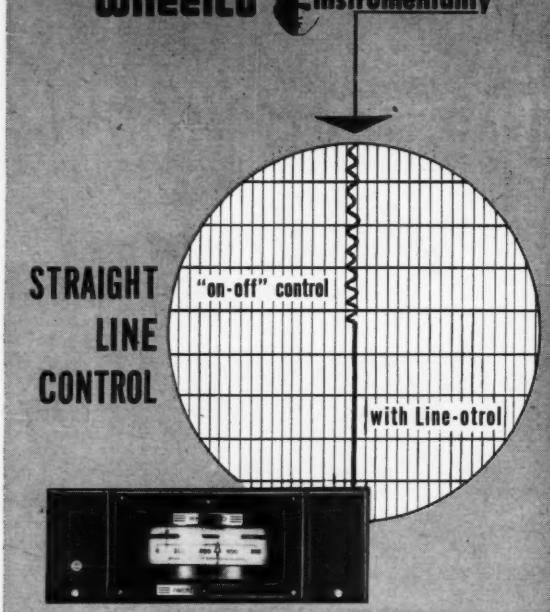

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SELECTING CONTROL VALVES

Continued from page 897

valve are very different from the design features in a shut-off valve. Double-seated valves are used to reduce the effect of the unbalance force caused by the pressure drop across the valve. Better throttling control is the net result. At the same time, it is not possible to cause both seats in a double-seated valve to seat and shut off together. It is possible sometimes to bottom both seats at one temperature, but a change of a few degrees in temperature causes slight changes in dimensions and the valve no longer shuts off tight. When the valve size is 1 inch or larger and the minimum flow requirement is more than ½ of 1 percent of the maximum flow, double-seated valves are usually called for. If tight shut off is required in the larger sizes, internally-balanced angle valves are available. These valves have an upper temperature limit of 300 deg. F. Partially balanced valves are available with small inner valves which can be used on steam and clean, hot gas-service. Fig. 3 shows a chart for rapid determination of unbalance loading in a single-seat valve.

Rangeability

The following conditions must be known to determine the valve rangeability required by the process: Pressure conditions are required for rating and sizing information; flow rates also are necessary for computing the size of the valve trim. Sizing a valve for a given process means finding the maximum and minimum flow coefficients required to give the desired control of the process. It is not sufficient to know the maximum and minimum flow rate and the maximum and minimum inlet pressure drop; it is necessary to know the three factors together.

16. *Maximum flow rate.* The excess capacity required for good control depends on the type of control system. It is customary to add about 25 percent to the maximum flow rate in computing the required maximum flow coefficient. Remember that valves increase in capacity in about 60-percent increments. This is the same order as for pipe capacity. In many installations, increasing the valve size does not increase the through-put in the system very much. The reason for this is that with increased through-put the pressure-drop losses in the system increase also. Again, the head-pressure curves of pumps drop with increased discharge so that the head pressure on the system falls off with the increase of flow, making less pressure-drop available for the valve.
17. *Normal flow rate.*
18. *Minimum flow rate.*
19. *Pressure drop at maximum flow rate.*
20. *Pressure drop at normal flow rate.*
21. *Pressure drop at minimum flow rate.*
22. *Upstream pressure with valve open.*
23. *Upstream pressure with valve closed.* This is usually understood to be the maximum pressure that can be locked up in the system. In a locked-up system the pressure can be increased by an increase in ambient temperature or by exposure to sunshine. In a liquid-filled system the hydraulic effect, called "water hammer," occurs if any valve in the system is opened or closed rapidly. The "water hammer" passes like a pressure wave through the piping system. The amplitude of this wave is greater than the static pressure. There are formulas for computing the increase in pressure. An approximate figure is that the increase in pressure in psi. is equal to 60 times the velocity in feet per second.
24. *Downstream pressure with the valve closed.* A control valve cannot control a fluid unless it creates a pressure drop. The rangeability of the over-all system decreases rapidly if the upstream pressure decreases as the valve opens. Consideration of the plug characteristic becomes important if the upstream pressure with the valve open is 75 percent or less of the upstream pressure when the valve is closed. Pressure-drop loss increases as the square of the through-put increase. In the design or lay-out stage of a process, it is difficult to establish the true pressure conditions. It is necessary to recognize this when specifying a valve. Actual operation will indicate whether the chosen

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*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

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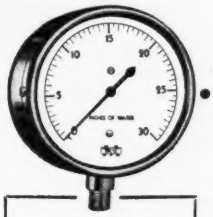

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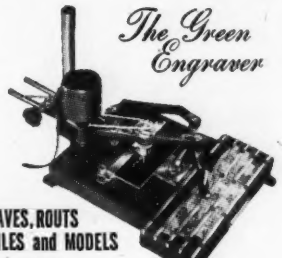

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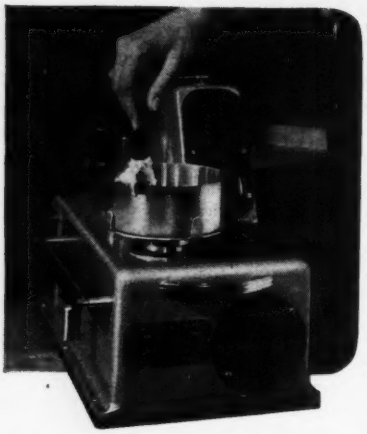

Weighing large groups of small animals in the laboratory is a slow, time consuming task when done on ordinary laboratory balances. The Shadograph (illustrated) simplifies and speeds up the work and saves time for more important work . . . does the job in a fraction of the old method. Immediate stop reading is recorded the instant the animal is placed upon the shadograph. Equipment is available in two models, one for mice, chicks, frogs and small rats; another model for large rats, hamsters and guinea pigs. Also used for formula compounding and blending for all types of products in the chemical field. Complete details and specifications to fit your operation are yours if you write.

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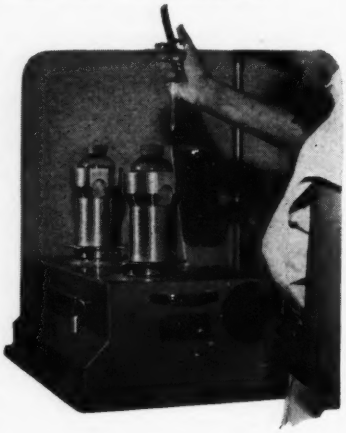

Shadograph balancing of cups reduces centrifuge vibration . . . cuts time and repair costs. With your centrifuge turning at 3000 or more r.p.m. even small weight variations build up tremendous force. They can seriously damage the centrifuge . . . make the use of other equipment impossible and shake the machine to pieces in a short time. Prevent this by establishing precise equilibrium with the Shadograph. The model (illustrated) has an over and under dial balanced at the three-quarter mark. You place cups on the platters and fill to balance. It's quick, easy and accurate. Specifications to your requirements. Write for details for your specific needs.

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valve size is adequate. The true pressure values then can be determined and a valve of the correct size installed.

25. *Maximum shut-off differential pressure.* When considering the use of a single-seat valve, it is necessary to know this value. Compute the force required and the air loading on the diaphragm air-motor to obtain good control.

C. Standards and Codes

Determine the piping standards, safety standards, and other regulations or codes concerning the area in which the valve is to be installed. Restrictions are placed on the choice of materials and ratings of equipment by insurance underwriters and good engineering practice. For example, cast iron may not be used in areas where inflammable fluids are handled. If a fire should occur, the cast iron might shatter, causing additional damage. Steel is used in place of cast iron because steel will not shatter.

26. *Body material and rating.* From the foregoing facts concerning pressure, properties of the fluids, and codes, it is possible to select the body material and rating. The nominal valve size is usually smaller than the nominal pipe size of the line. An installation of this kind has high stress concentration in the valve body. These stresses may be caused by the mechanical movements and moments and temperature expansion of the system. It is sometimes advisable to use a body rating greater than that required by the maximum fluid pressure.

27. *Trim material.* Trim material refers to the component parts inside the valve which are in direct contact with the fluid. The choice of material is determined by economics, erosion, and corrosion. When erosion and corrosion are considered, the material is chosen which stands the erosion in preference to the material which stands the corrosion. The pressure drop across the valve causes high fluid velocities which accentuate the erosive effect. Most corrosion data available do not consider the effect of fluid velocity. Corrosion rates increase rapidly when the liquid velocity is greater than 5 feet per second. The choice of trim materials usually is based on the over-all experience and background for a given installation.

28. *Plug material.*

29. *Seat material.* Usually seat rings are screwed into a valve body with a litharge and glycerin cement. If, for product purity or any other reason, the use of litharge (which is a lead oxide) is undesirable, some other screw-thread lubricant may be used. It is important to point out this fact to the valve supplier.

30. *Stem material.*

31. *Plug-guide material.*

32. *Hard facing.* The valve plug and the valve seat have hard facing in erosive service. Hard facing is the oxyacetylene or electric welding of special wear-resisting alloys to parts which are subjected to wear. Because of the protection obtainable by hard facing, equipment can be made with less-expensive base metals and still offer maximum service life. The usual hard-facing material is Stellite No. 6 or equal. For steam service, Stellite is recommended to overcome the "wire drawing" of the seats. When the valve plug is nearly on its seat, steam has a tendency to channel grooves into the seat ring. This is more common with V-ported than with solid plugs.

33. *Stuffing-box parts material.*

34. *Gasket material.*

35. *End fittings.* 1½-inch nominal pipe size and smaller valves commonly have NPT female screw-thread end fittings. Valves 2 inches and larger have flanged end fittings in the commercially available flange ratings. Flanged ends are available for valves smaller than 2 inches in size and are recommended for stainless-steel bodies and for ease of installation and removal for maintenance. Usually valves are supplied with oil or grease protective coverings on the internal parts. On oxygen service it is imperative that the valve is supplied clean and free of all traces of oil.

D. Flow Diagram

Prepare an installation sketch of the process to be controlled. Indicate on the sketch the pressure at the principal

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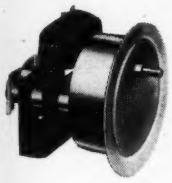

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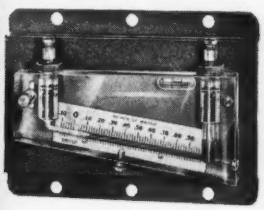

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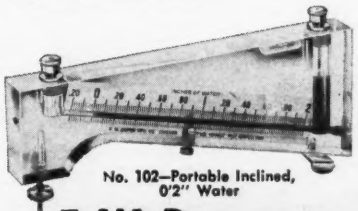

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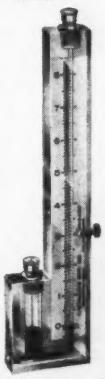

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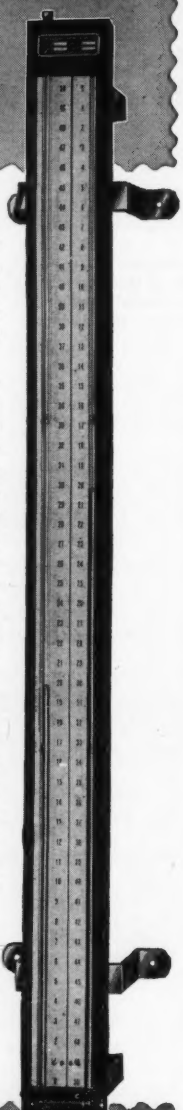

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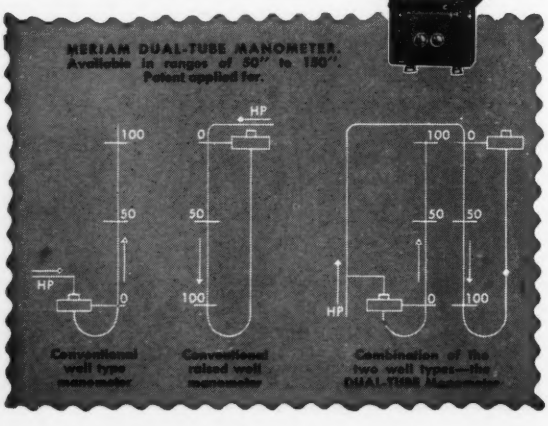

stages of the cycle at the maximum and minimum flow rates.

Automatic control valves generally are installed as a by-pass around a manual control valve. The manual valve is directly in the line of flow. In order to be able to remove the control valve for maintenance or repair, gate valves are on both sides of the control valve. This installation is rather expensive and modern practice is toward eliminating the by-pass arrangement, using only a control valve. Other shut-off valves in the system are used to isolate the section when it is necessary to remove the control valve. This is done where operation maintenance is adequate or where there are definite shut-down periods for overhauling of equipment. The one difficulty that may arise from the control valve in the by-pass installation is inadequate capacity. If the pipe and fittings in the by-pass are of the same size as the control valve, 40 percent of the pressure drop through the by-pass will be in the pipe and fittings. The manual globe-valve in the run has considerably more pressure-drop available and so gives more through-put. Consideration of the installation sketch will draw attention to the kind of control that is to be expected in the system and will, with the knowledge of the process, indicate the inner-valve characteristic required.

E. Size and Rangeability

Size the valve and compute the required rangeability of the valve and the estimated rangeability of the system.

Rangeability is the ratio of the flow coefficient at maximum flow rate to the flow coefficient at minimum flow rate. The valve sizing information supplied by valve vendors is usually in the form of slide rules or nomogram charts. The required valve size can be determined from these. However, it is necessary, in order to have a better understanding of the required functioning of the valve, to compute the required flow coefficient. Compute the flow coefficient for maximum flow and for minimum flow. The required rangeability is the ratio of the maximum to the minimum. Commercially available valves have a rangeability ratio from 30 to 1 to 50 to 1. This is determined by the clearance between the valve plug and the valve seat. In stainless-steel trim, it is not practical to decrease the clearance to less than 0.004 inch; galling occurs if less clearance is used. The system rangeability should be computed if sufficient information is available. The formula for *system rangeability* is:

$$R_{SYSTEM} = R_{VALVE}\sqrt{\%VALVE\ PR.\ DROP/100}$$

This shows that if the required rangeability in the system is large, sufficient pressure drop must be available across the valve.

36. *Valve-plug characteristic.* There have been many opinions expressed for the choice of the characteristic of a valve plug. Experience alone can determine the most desirable characteristics for a given installation.

37. *Valve nominal size.* Valve suppliers tabulate the flow coefficient of various valve sizes. The flow coefficient for a nominal size varies with the characteristic of the valve plug. Valves with an equal-percentage plug characteristic usually have less capacity than linear plugs. Quick-opening plugs in high-lift valves give maximum capacity.

F. Leakage

If the valve is 1 inch or larger, compute the leakage for a double-seated valve at ½ of 1% of the valve capacity. If this is excessive, consider the use of a single-seated valve.

38. Single- or double-seated valve.

G. Additional Features

39. *Radiation bonnet for cooling.* If the fluid temperature is higher than 450 deg. F., it is necessary to cool the stuffing box of the valve. No valve-stem lubricant or stem packing is available for higher temperatures. On installing radiation bonnets, care must be taken that the thermal insulation on the line, which may be put around the valve body, is not on the radiation bonnet.

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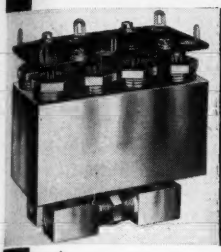

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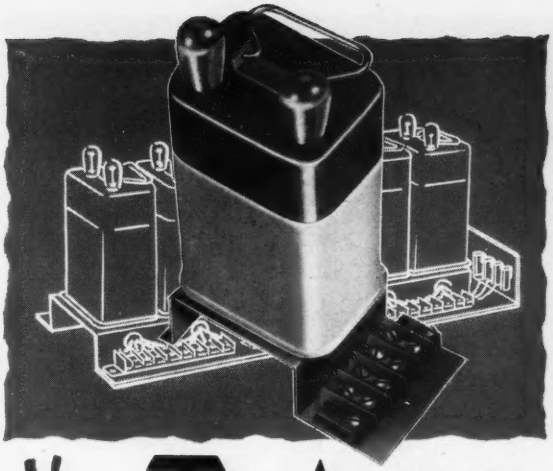

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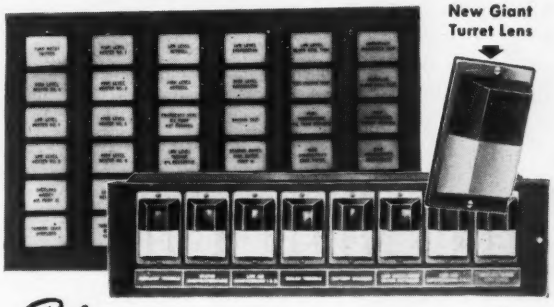

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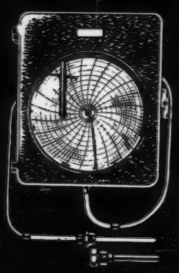

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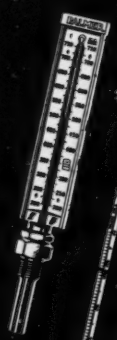

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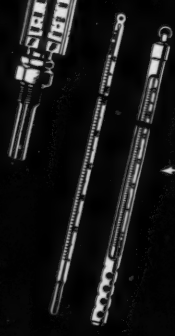

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40. *Extension neck bonnet for cold insulation.* If the fluid in the line is below 32 deg. F., moisture from the air freezes on the exposed parts. This ice is a fairly good heat insulator so that the ice keeps building up higher along the bonnet to the valve stem and prevents valve motion. This can be overcome by the use of an extended neck on an exposed bonnet. When special bonnets are considered, extreme care must be taken to choose a valve lubricant which does not stiffen at the low temperature.

41. *Type of packing.* A great variety of valve-stem packing has been developed. The most common form is long, blue, African asbestos fiber impregnated with oil and graphite. Formerly, this was available only in rope form and lengths were cut to size and put in the stuffing box. Today, formed rings are available. These are much more convenient and function better. There is one serious problem involved in the use of asbestos packing with graphite on stainless-steel valve stems. It has been observed that there is an electrolytic reaction between graphite and stainless steel. The result is a deep pitting of the stainless steel. In general, the corrosion occurs when a valve is packed and stored over a period of several months. The method of overcoming this corrosion is to impregnate the packing thoroughly with a light lubricating oil. This corrosion usually is not observed when the valve is installed and operating. Teflon now is being used in a number of different ways—shredded, in washer form, and in a patented seal form. There are many advantages in using Teflon, although the upper temperature limit is 350 deg. F.; it has low friction-coefficient and is chemically inert.

42. *Bellows seals.* There are applications in which it is essential that there be positively no leakage in the stuffing box. It may be possible to use a bellows seal. They are available in "347" stainless steel, "Monel," and other resistant materials. Bellows seals were developed to give positive sealing. The principal application has been on vacuum service where air contamination is a serious problem. Another use has been in pilot-plant work where it is essential that no material is lost. Bellows are used in "Freon" service where leakage is expensive. The use of bellows reduces the maintenance cost on valves because the cost of stuffing-box maintenance and repacking is eliminated. It must be remembered that sludge formation or solidification can affect the functioning of the bellows.

43. *Type of lubricant.* The lubricant seals the fluid in the stuffing box. If no lubricant were used, the stuffing-box gland follower would have to be pulled down so firmly that the stem friction would be large; thus, the valve could not move in small increments. Control valves require lubricants made especially for control valves. It is not desirable to use plug-cock grease which has the same service ratings; plug-cock grease has much too much body and causes excess hysteresis. Lubricants are made that are not soluble in the various classes of fluids. The lubricant used must be specified for the type of fluid. A new type of lubricant used recently is Silicon grease. Silicon grease has chemical inertness and stable viscous properties. Field trials are not complete, so the use of Silicon grease is to be advised only for trial purposes. The advantages are stability and long life, and one type of grease can be used on many fluids.

44. *Lubricator with isolating valve.* If the fluid pressure is more than 150 psi., it is advisable for safety to use an isolating valve with a lubricator. There is a small ball-check valve in the lubricator, but it is not fully reliable under pressure. The isolating valve is used to shut off the fluid pressure from the lubricator when inserting additional lubricant in the lubricator.

45. *Flushing or drain taps.* It is sometimes convenient to have flushing or drain taps on a valve to be able to relieve the pressure from the valve body before removing it from the line. The tap also offers a convenient place for mounting a pressure gage.

46. *Steam jacketing.* If the liquid is viscous, it may be desirable to have steam jackets on a valve body. They are available on most valves.

47. *Valve positioner.* About 1 out of 10 valves gives improved performance with a valve positioner. It is advisable to have a factory-mounted positioner on a valve because

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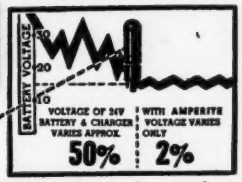

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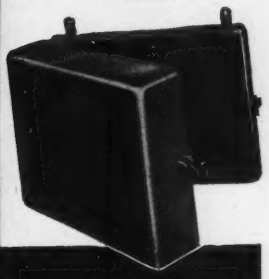

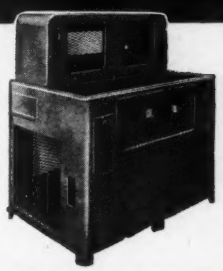

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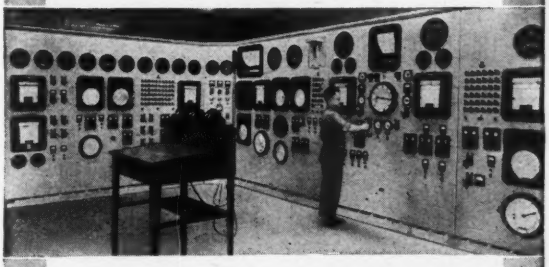

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it will be available at start-up. If it is not necessary, it can be removed and mounted on another valve. On ordering a valve positioner, the air set, by-pass, and gages are considered as additional equipment and must be ordered as such.

48. *Manual handwheel or jacking screw.* It is sometimes desirable to be able to operate the valve manually. It is possible to mount a handwheel on a diaphragm air-motor case to push down and compress the spring. The spring returns the valve stem. Spring failures are practically unknown today.

49. *Continuous connected handwheel.* If it is necessary to operate the valve both up and down, continuous handwheels are available. These are not connected to the valve stem. When the valve is operated by air, the handwheel does not turn.

50. *Special treatment or handling.* On many chemical services it is important that the exact materials of construction are known, including the surface coatings. Occasionally these coatings may be objectionable. For example, all oxygen valves must be oil free. It is necessary that valves for this service be disassembled after final test, thoroughly degreased, and reassembled.

51. *Spare parts.* Most valve vendors supply a standard spare-parts list. It is good practice to have a reasonable supply of spare parts available. The spare parts required can be determined from the service. The most common spare parts are a valve plug, stem, seats, packing, and lubricant.

Having obtained the information on the operating conditions, it is possible to prepare a general control-valve data sheet. From this sheet, a control-valve specification can be written. Considering the specification with respect to known available equipment, it is possible to select a specific item from a specific manufacturer. It is advisable to offer the control-valve data sheet to the manufacturer for his consideration. This allows the manufacturer to express approval of the valve selection or to recommend a more suitable model.

INSTRUMENT ELECTRONICS

Continued from page 899

The bandwidth requirements of time modulation depend on the pulse shape because the pulses are transmitted. As the pulses must be sharp, the bandwidth is relatively large. However, the signal-to-noise ratio is good and it is relatively easy to use a series of pulses to transmit 20 or 30 signals on one channel. Fig. 11-5, B shows a multichannel, or *multiplexed*, time-modulation system. The modulation displacements of signal pulses of two channels are shown. Each is used with the same marker.

Pulse-time modulation with multiplexing is being used in instrumentation for transmitting meter readings, thermocouple outputs, strain-gage outputs, and other measurements whose frequency components no not exceed a few thousand cycles per second.

Demodulation

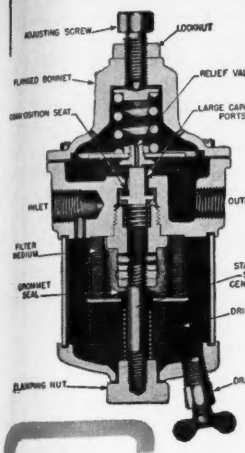
Demodulation, or detection, is the process of recovering the desired signal from a modulated wave. It is the opposite of modulation, but is identical to modulation in theory and principle.

As explained, modulation always produces new frequencies, called sideband frequencies; the modulator receives the carrier and signal frequencies and produces the sum and difference sideband frequencies. As the sideband frequencies are r-f. waves, they all travel through space from transmitter to receiver when radiated from an antenna.

The receiver of a radio wave receives the carrier wave plus the sideband waves. It "mixes," or "modulates," these to produce sum and difference frequencies again. However, the *difference* frequency now is the desired signal. Thus modulation and demodulation are identical processes in physical principle.

Demodulation of Amplitude-modulated Waves

As mentioned in Chapter 10, in the discussion of heterodyning and beat-frequency oscillators, sum and difference



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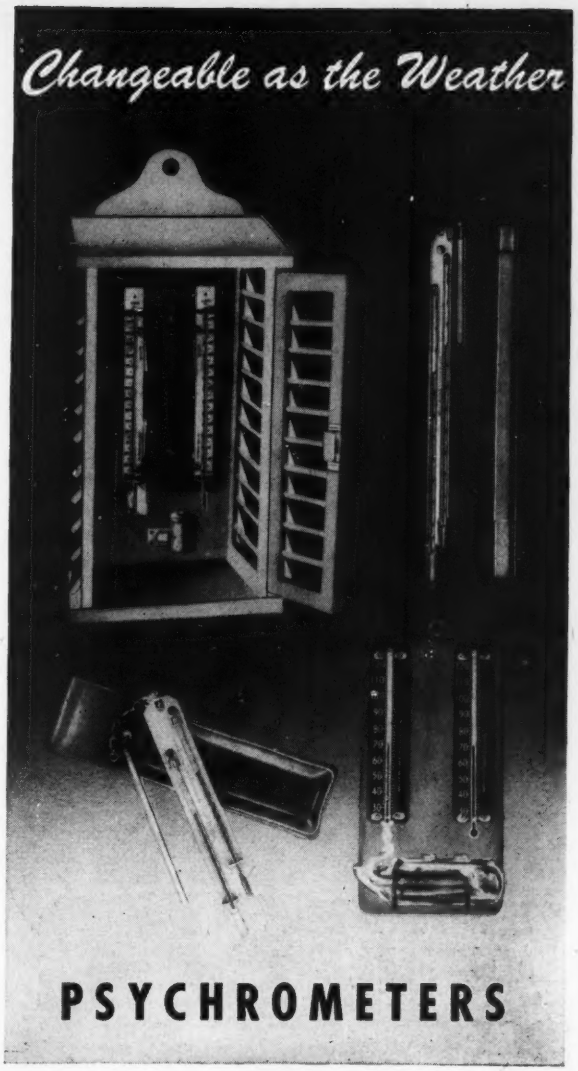

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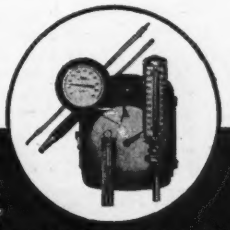

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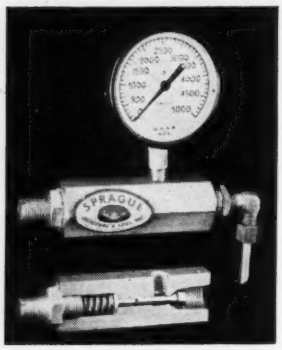

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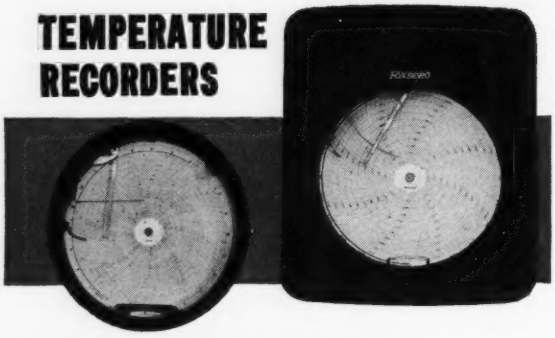

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frequencies are produced only when two frequencies are fed into a *nonlinear device*. Any nonlinear device can be used as a modulator or demodulator for a-m. waves. All a-m. modulators and demodulators are nonlinear devices.

Diode detector. The most common detector is simply a diode or rectifier followed by a capacitor and resistor, as in Fig. 11-6. The input is the modulated r-f. wave. The capacitor C by-passes the r-f. wave to ground. The RC time constant is chosen to permit the capacitor voltage to follow the envelope of the modulated input wave, which is the demodulated signal. As a diode or rectifier has a linear characteristic above cut-off, it is called a linear detector—even though it operates at the nonlinear cut-off point.

Plate-circuit detector. A plate-circuit detector (Fig. 11-7) is a biased amplifier. If the amplifier is biased to cut-off, as for class-B operation, it functions like a diode, passing only positive-going portions of the wave. The result is diode detection plus amplification. For strong signals, the tube operates on a linear portion of its curve and is a distortion-free linear demodulator, as is the diode detector.

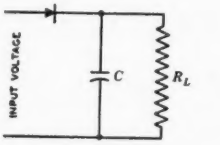

Fig. 11-6. Diode detector.

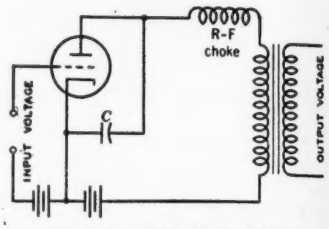

Fig. 11-7. Plate-circuit detector.

Square-law detection. When the amplifier is not biased to complete cut-off, or when the input signal is small in amplitude, the tube in Fig. 11-7 operates over a small, curved portion of its characteristic curve. As a curve is not a straight line, a certain amount of signal mixing occurs and demodulation results. However, a distortion term equal to twice the desired envelope frequency is produced. This is not true when demodulating *single-sideband* waves (waves in which only one of the two sidebands are transmitted). For single-sideband waves, the square-law detector produces less distortion than a "linear" detector. Note that the term "linear detector" refers to a nonlinear device which is linear everywhre but at one point of discontinuity—like an angle.

The advantages of a plate-circuit detector over a diode detector are amplification and higher input impedance. However, the diode detector is more simple.

The plate detector is used commonly in *vacuum-tube voltmeters* in which the plate current of a vacuum tube is calibrated in terms of the d-c. or a-c. input voltage to the grid. The primary advantage is the high input impedance of the tube, permitting voltage measurements on circuits while drawing little current from the circuit.

Demodulation of Frequency-modulated Waves

The demodulator of a frequency- or phase-modulated wave is called a frequency *discriminator*. Fig. 11-8 shows a Foster-Seeley discriminator. The signal is applied to the center of the tapped resonant tank. The tank acts as if the top half of the tank were tuned to a slightly higher frequency than the lower half of the tank. Thus as the fre-

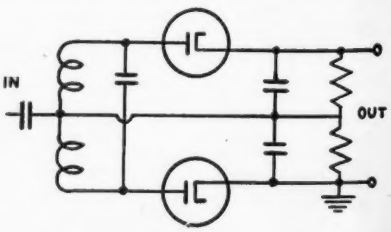

Fig. 11-8. Foster-Seeley discriminator.

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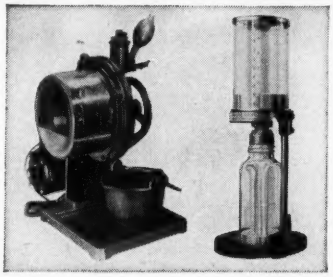

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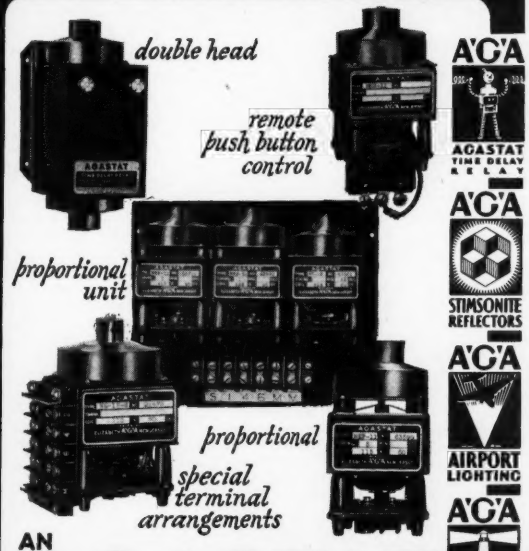

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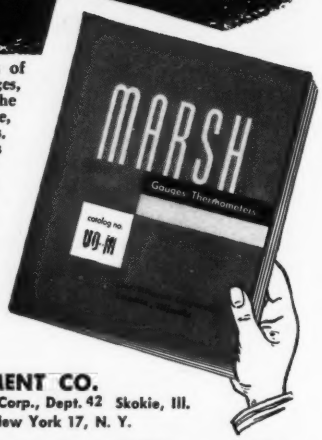

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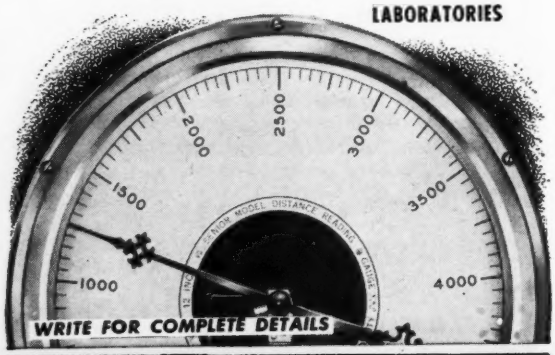

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quency variations occur, one diode conducts more than the other, converting the frequency variations into the desired amplitude variations.

A disadvantage of the Foster-Seeley discriminator is that amplitude variations in the incoming f-m. signal also produce amplitude variations in the output, thus producing noise. For this reason the incoming wave is maintained at a constant amplitude by a *limiter* circuit preceding the discriminator.

A discriminator called the *ratio detector* overcomes the amplitude sensitivity of the Foster-Seeley discriminator and can be used without a limiter. In the ratio detector a stabilizing capacitor across the output automatically biases the diodes so that amplitude variations are eliminated.

Demodulation of Time-modulated Waves

The t-m. demodulator must translate the position changes in a train of pulses into corresponding amplitude variations. There are several methods for doing this. One method uses a multivibrator which produces a sawtooth signal. The incoming signal is added to the slowly rising sawtooth waveform. Thus the output amplitude depends on the position of the pulse, accomplishing demodulation.

Another method uses a modified cathode-ray tube called a *cyclophon*, which has a series of apertures around the circumference of a plate. The electron beam is rotated around the plate. The instantaneous position of the incoming pulses causes the beam to cover more or less of the aperture, from which the output is taken.

Continued next month

TEST ITEMS—XI. SIGNAL-SHAPING CIRCUITS

11-1. In order to impose a signal on a radio-frequency carrier wave, it is necessary to change the wave in
(a) amplitude
(b) frequency
(c) phase
(d) any of the above

11-2. The bandwidth of a modulated wave refers to the
(a) carrier frequency of the wave
(b) modulating frequency of the wave
(c) range of frequencies in the wave
(d) amplitude of the wave

11-3. Which of the following statements about bandwidth of a modulated wave is true?
(a) Bandwidth decreases as amount of transmitted information increases.
(b) Bandwidths should be as narrow as possible.
(c) Bandwidths of a-m. waves are larger than f-m. waves used for the same service.
(d) All the above.

11-4. The bandwidth required by an amplitude-modulated wave is
(a) the carrier frequency
(b) the modulating frequency
(c) twice the highest modulating frequency
(d) four times the highest modulating frequency

11-5. Which of the following statements about the degree of modulation of an a-m. wave is true?
(a) It is ratio of maximum deviation in amplitude to the normal amplitude.
(b) It should be as large as possible for maximum signal-to-noise ratio.
(c) It should not exceed 100 percent.
(d) All the above are true.

11-6. Which of the following statements about f-m. modulation is true?
(a) The f-m. receiver can receive a p-m. signal.
(b) The bandwidth is narrower than for amplitude modulation.
(c) One pair of sidebands is produced for each modulating frequency.
(d) Bandwidth is independent of frequency excursion.

11-7. A reactance tube is
(a) an amplifier that acts like a reactance
(b) a rectifier with a reactance at the output
(c) an oscillator
(d) a frequency discriminator

11-8. The advantage of pulse-time modulation is
(a) ease of multiplexing
(b) bandwidth independent of pulse shape
(c) narrow bandwidth
(d) all the above

11-9. A linear detector is a device with
(a) a straight-line characteristic at all points
(b) a straight-line characteristic at all points but one
(c) any linear characteristic, such as a square-law curve
(d) linear amplification

11-10. The advantage of a plate-circuit detector over a diode detector is that the former is
(a) a linear detector for small signals
(b) a linear detector for large signals
(c) an amplifier as well as a detector
(d) simpler and more economical

11-11. Demodulation of frequency-modulated waves is done by the
(a) diode detector
(b) square-law detector
(c) discriminator
(d) cyclophon

11-12. The advantage of a ratio detector over a Foster-Seeley discriminator is that the former
(a) demodulates both f-m. and p-m. waves
(b) demodulates both a-m. and f-m. waves
(c) is insensitive to amplitude variations in signal
(d) is a linear detector

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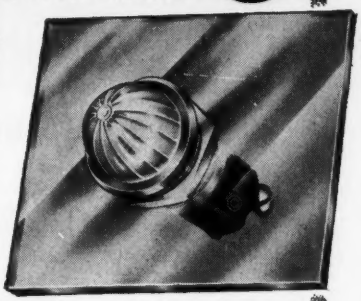

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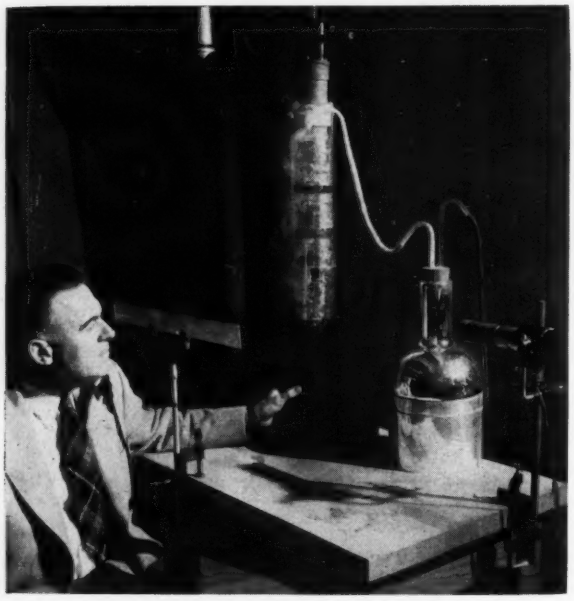
INSTRUMENTS ON THE MARCH

New Principles, Applications, Non-commercial Developments

Liquid Helium II

WASHINGTON, D. C.—According to Technical Report 1642, Dr. J. R. Pellam of the National Bureau of Standards has developed a simple and accurate mechanical technique for investigating "second sound," that unique wavelike process of heat transfer occurring only in helium II near absolute zero. The new technique uses the well-known thermal Rayleigh disk method to measure the torque exerted on a light-weight disk suspended in the path of standing waves of second sound. It thus constitutes the first mechanical method for detection of this phenomenon.

Helium liquefies at 4.2 deg. K., the lowest liquefaction temperature of any substance. Between 4.2 and 2.19 deg. K., liquid helium behaves as a normal fluid and is known as helium I. Below 2.19 deg. K., however, helium I changes into the liquid form known as helium II. Helium II is so unlike any other fluid that it is often referred to as a fourth



state of matter or as the quantum fluid. It acts as though it has no viscosity, flowing apparently without friction through virtually vacuum-tight openings and up the side of a containing vessel at remarkable speed in seeming defiance of gravity. Its direction of flow through narrow orifices may be controlled by temperature differences.

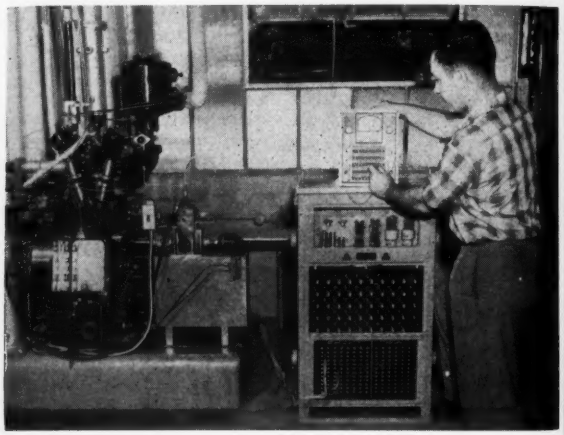
One of the unusual properties of helium II is its high thermal conductivity—three million times that of helium I and much greater than that of any other substance. Heat is transferred by a kind of wave motion analogous to sound and known as second sound.

In the new apparatus, a light-weight mirrored disk is suspended by a thin torsion wire at the midpoint of a horizontally oriented cylindrical glass cavity containing helium II. Standing waves of second sound are set up within this cavity when heat oscillations of the proper frequency are introduced by means of an electrically heated carbon-resistor strip which makes up one end wall of the cavity.

The NBS experiments have significant theoretical implications. They provide a convincing experimental verification of the two-fluid hypothesis of helium II.

48-point Temperature Monitor

WASHINGTON, D. C.—A temperature-monitoring device, recently developed at the National Bureau of Standards electronic instrumentation laboratory, flashes a warning if the temperature at ony one of 48 remote points rises above an individually predetermined safe value, according to Technical Report 1596. An alarm light or bell goes on if any point becomes too hot. Location of trouble is shown by an indicating unit. Actual temperature at any single point can be measured by a plug-in meter. The monitor covers the range from 100 to 400 deg. F. A mechanical scanning switch with a 5-second period samples each of the 48 thermocouples.



Large Testing Machine

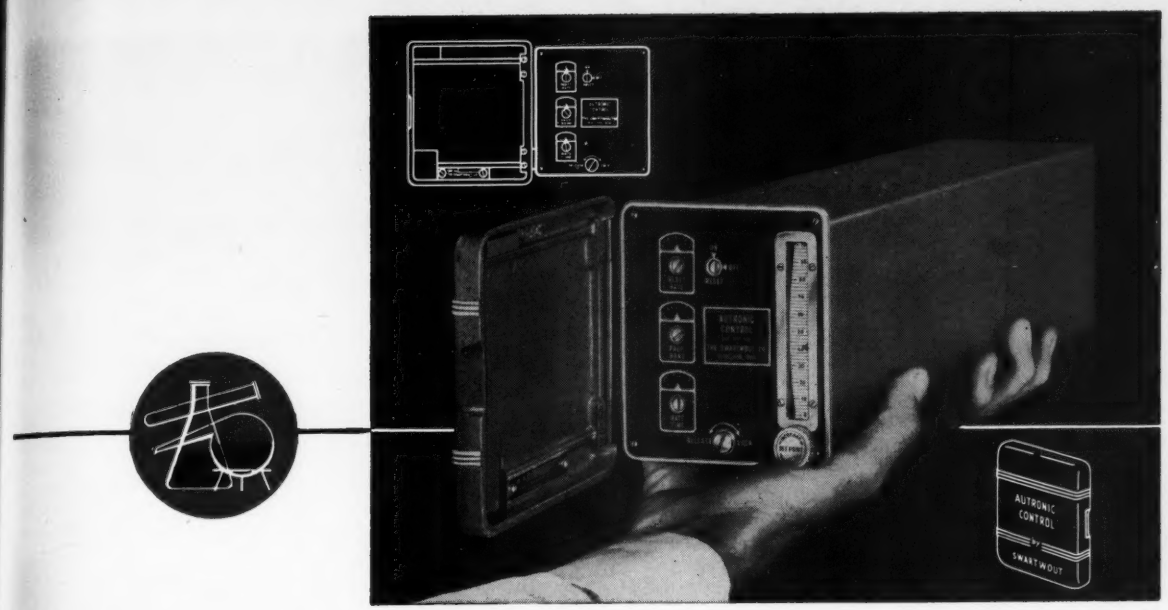
BETHLEHEM, Penna.—The world's largest vertical universal testing machine is to be installed on the Lehigh University campus. A new building will house a 5,000,000-lb. hydraulic tension-compression machine to be constructed at an estimated cost of $400,000, accessory equipment valued at $300,000, and modern laboratories. Design and construction will be shared by Bethlehem Steel Company, Baldwin-Lima-Hamilton Corporation, and Professor William J. Eney of Lehigh University.

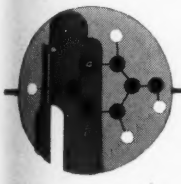
Wide-range Radiation Detector

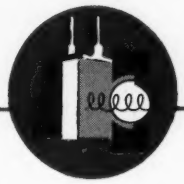
CHICAGO, Ill.—Leonard Reiffel, physicist at Armour Research Foundation of Illinois Institute of Technology, has invented a wide-range radiation detector which can detect, on a single scale, radiations which vary in strength from 0.1 milliroentgen to 1,000 roentgens. This sensitivity ratio of 10,000,000 to 1 is valuable because radiation varies sharply as its source is approached.

Radiation-instrument Department Store

NEW YORK, N. Y.—The Radiac Company, 489 Fifth Ave., New York City, is the first atomic-instrument department store in the world. Among the many types of radioactivity-detection instruments offered for sale to the public is the "Scintillometer," which is so sensitive that it can detect the minute radioactivity normally present in blood.







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Manufacturers' New Literature

In this department we report new literature, pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 943.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

Temperature

U-614 **Thermocouples.** 44-page illustrated Catalog EN-62 covers maker's large line of thermocouples and assemblies. Includes general recommendations for tube and well materials, assemblies for specialized applications such as laboratory standards and molten-metal measurement, replacement guide, accessories, and instruments for indicating, recording, and controlling.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Penna.

U-615 **Temperature Measurement.** 12-page Bulletin 404 covers "Microsen" temperature indicators and recorders. Includes data on power-operated pointer, sensitivity, design features, applications, specifications, and thermocouples. —Manning, Maxwell & Moore, Inc., Stratford, Conn.

U-616 **Thermocouple Potentiometer.** 2-page Bulletin GEC-245B covers features, operation, and application of maker's potentiometer "Type PJ-1" for use primarily with thermocouples.—General Electric Co., Schenectady, N. Y.

U-617 **Thermocouples.** 20-page Bulletin GEC-714 covers maker's large line of thermocouples, tubes, insulators, extension wire, connectors, and heads. Includes selection data.—Apparatus Dept., General Electric Co., Schenectady, N. Y.

U-618 **Resistance Thermometers.** 8-page Bulletin GEC-835 illustrates and describes maker's resistance-thermometer indicators, controllers, and protectors. Includes principles, operation, and specification data.—General Electric, Schenectady, N. Y.

U-619 **Monitoring Pyrometer.** 8-page Bulletin 4703 illustrates and describes "Alnor Pyrotac" control unit that automatically monitors up to 20 individual temperature points a minute. Includes features and applications.—Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.

U-620 **Thermostats.** 2-page brochure illustrates and describes maker's snap-action thermostats. Includes application, principle, and specifications.—Stevens Mfg. Co., Inc., Mansfield, Ohio.

U-621 **Thermoscopic Crayons.** Supplementary instruction sheet covers recommended uses of "Tempilstiks" in a variety of industrial and research applications.—Tempil Corp., 132 W. 22nd St., New York 11, N. Y.

U-622 **Temperature Test Cabinets.** 12-page folder ADV. 824 contains brief dscriptions of maker's large line of liquid-control systems, test equipment, temperature cabinets, etc.—Bowser Technical Refrigeration, Terryville, Conn.

U-623 **Temperature Control.** 4-page Bulletin 631 illustrates and describes maker's "Mercury-Thermo-Regulators" which use mercury-in-glass column to close relay at adjustable temperature. Includes features, operation, and applications—including refrigeration protection.—Philadelphia Scientific Glass Co., 4 Eckard Ave., Abington, Penna.

Pressure

U-624 **Pressure Control.** 4-page Specification Sheet 710 illustrates and describes Brown indicating and recording pressure gages with "Air-O-Line" pneumatic control. Includes construction and engineering details.—Minne-

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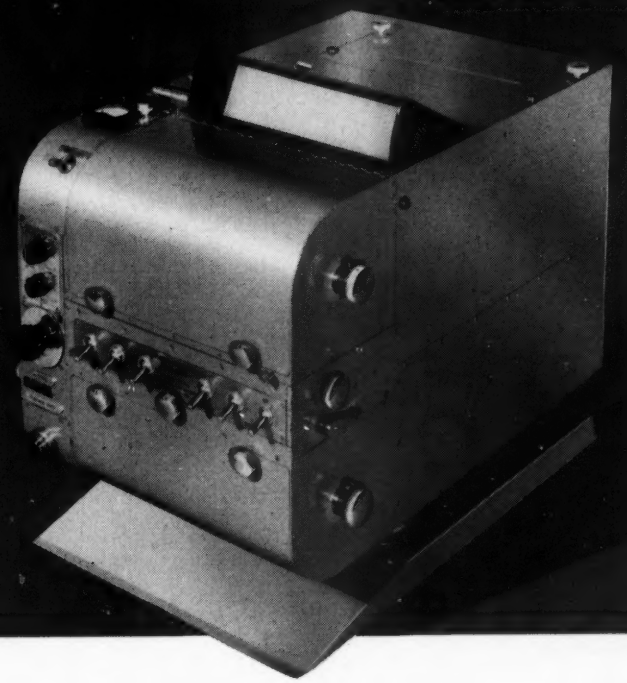

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This fine instrument was designed with full knowledge of the recording problems encountered in laboratory, industrial and aircraft testing. It will record up to 36 separate channels of data. It is 11½ inches wide, 11½ inches high and 17 inches long. For use in this Oscillograph, Midwestern offers a wide variety of precision galvanometers with undamped natural frequencies up to 3500 cps. Write for complete oscillograph and galvanometer specifications.

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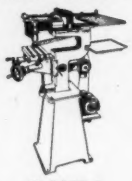
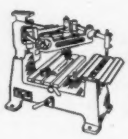


Model 2D-4

Model UE-3



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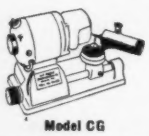

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NEW LITERATURE

apolis-Honeywell Regulator Co., Industrial Div., Sta. 40, Wayne & Windrim Aves., Phila. 44, Penna.

U-625 **Pressure Control.** 4-page illustrated Specification Sheet 709 describes Brown indicating and recording gages with "Electr-O-Vane" control. Includes construction and engineering details.—Minneapolis-Honyewell Regulator Co., Industrial Div., Station 40, Wayne & Windrim Aves., Phila. 44, Penna.

U-626 **Vacuum and Pressure Control.** 2-page brochure describes "Cartesian Manostat No. 7" with automatic control of vacuum or pressure for laboratory. Also described is flash-vaporization equilibrium still.—The Emil Greiner Co., 20 N. Moore St., New York 13, N. Y.

U-627 **Pressure Transducers.** Bulletin 352 illustrates and describes "Type PT" pressure transducers which move brush on potentiometer (voltage-dividing resistor) in accordance with pressure change.—Rahm Instruments, Inc., 12 W. Broadway, New York 7, N. Y.

Flow

U-628 **Variable-area Flowmeters.** 12-page illustrated Catalog 40 describes armored "Flowrator" for high-pressure flow-rate measurement. Includes section on alarms, magnetic follower, transmitters, etc.—Fischer & Porter Co., Hatboro, Penna.

U-629 **Variable-area Flowmeters.** 2-page Bulletin 12C covers features of maker's new micro flowmeter series. Includes table of flows.—Technical Equipment Co., 4348 San Pablo Ave., Emeryville 8, Calif.

Optical

U-630 **Light-intensity Control.** 12-page illustrated Bulletin D 851 N describes complete line of "Powerstat" non-interlocking light-dimming equipment with outputs from 1000 to 30,000 watts. Includes features, specifications, and applications.—The Superior Electric Co., Bristol, Conn.

U-631 **Smoke Recorder.** 2-page Bulletin 512 gives features and specifications of "SIR-62" smoke recorder.—Ess Instrument Co., Bergenfield, N. J.

U-632 **Projectors.** Three 6-page brochures illustrate and describe models of maker's "Visual Cast" daylight projectors for wall, ceiling, or screen projection.—Victorlite Industries, Inc., 5350 Second Ave., Los Angeles 43, Calif.

Process Control

U-633 **Process Control.** 40-page Vol. 6 No. 1 issue of "Instrumentation" features 12 articles on process and quality control in chemical, oil, rubber, and manufacturing industries. Includes articles on graphic panels, time-proportioning, and program control, temperature test chambers, and valve testing.—Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Phila. 44, Penna.

U-634 **Recorders and Controllers.** 48-page edition of Catalog ND46(1), "Speedomax Type G Instruments For Measurement and Control," includes installation pictures in plant and laboratory, as well as specifications for latest additions to "Speedomax" line.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Penna.

Radioactivity

U-635 **Radioactivity Glossary.** 2-page bulletin contains glossary of 58 words used in field of radioactivity measurement.—Radiation Counter Laboratories, Inc., 5122 W. Grove St., Skokie, Ill.

Chemical Laboratory

U-636 **Laboratory Equipment.** 32-page Vol. 21 No. 5 issue of "The Laboratory" features articles on new "Electro-Analyzer" for multiple quantitative analyses, automatic burner-regulator, "Projectomatic" balance, and other laboratory equipment.—Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Penna.

U-637 **Laboratory Equipment.** 6-page issue of "Labitems" features article on "Equilibrium Flash Vaporization of Petroleum Crudes and Fractions" and descriptions of 15 new laboratory items—centrifugal pump, photoelectric colorimeter, etc.—Emil Greiner Co., 20 N. Moore St., New York 13, N.Y.

U-638 **Laboratory Presses**—4-page brochure illustrates and describes maker's hydraulic laboratory presses and accessories.—Wabash Metal Products Co., 1569 Morris St., Wabash, Ind.

U-639 **Laboratory Equipment.** 30-page issue No. 75 of "Cenco News Chats" features articles on "Minicorder" temperature recorders, "AO Spencer" spectrometer, dew-point tester, and other laboratory equipment.—Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

U-640 **Electric Stirrer.** Illustrated Bulletin 601 describes maker's "No. 601" portable electric reciprocating stirrer.—Research Appliance Co., Box 413 West View Road, Pittsburgh 9, Penna.

Chemical Process Analysis

U-641 **Infrared Spectrometer.** 32-page Bulletin 102 covers performance, accessories of new mobile "Model 112 Double-pass Infrared Spectrometer." Also covers applications of infrared spectroscopy, requirements of infrared instrumentation, and descriptions of available accessories.—The Perkin-Elmer Corp., Norwalk, Conn.

U-642 **Infrared Spectrometers.** 8-page Vol. 3 No. 3 issue of "The Perkin-Elmer Instrument News" features articles on unitized building-block design of infrared spectrometers, new applications of spectrometers, and use of "Model 21" in quantitative work.— The Perkin-Elmer Corp., Norwalk, Conn.

U-643 **pH Measurement.** 12-page Bulletin ND46-96-702 (1) describes installation and operation of pH measurement system of dehydrator water.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Penna.

U-644 **pH Control.** 12-page Bulletin

ND 4-96-709D illustrates and describes how L&N pneumatic control, using a "Speedomax" electronic recording instrument, automatically adjusts the flow of reagent to maintain pH at optimum value.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Penna.

Viscosity

U-645 **Viscosity Measurement.** 9-page brochure gives general applications of new "Ultra-Viscoson" that measures viscosity continuously by use of ultrasonics. Includes system requirements and price list.—Rich-Roth Laboratories, 673 Connecticut Blvd., East Hartford, Conn.

U-646 **Bubble Viscometer.** 4-page illustrated brochure describes features and operation of maker's bubble viscometers and tube holders for rapid reading.—Gardner Laboratory, Inc. 4723 Elm St., Bethesda, Md.

Speed and Frequency

U-647 **Tachometers.** 4-page Technical Data Sheet No. T4 describes principle of operation of maker's hand, portable, and fixed-installation tachometers; pictures many available models. Basic circuit and advantages are described in detail.—Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

U-648 **Tachometers.** 2-page brochure illustrates and describes new "O-Z" hand tachometers, including single-range tachometers for speeds from 30 to 4000 rpm., and universal tachometer with triple ranges from 25 to 30,000 rpm., or 30 to 40,000 rpm. O. Zernickow Co., 15 Park Row, New York 38, N. Y.

U-649 **Motor-speed Control.** 8-page Vol. 26 No. 12 issue of "The General Radio Experimenter" features article on motor-speed control by new ¾-hp. "Variac" autotransformer. Also use of "Variacs" in electrical engineering power laboratories.—General Radio Co., Cambridge, Mass.

Inspection and Testing

U-650 **Gaging.** 38-page illustrated booklet, "Dimensional Control and Gaging Policy" covers gaging policy, tolerances, reference temperature, gage specifications, ordnance practices, fixed gages, instruments, multiple semi-automatic and automatic gaging devices. Describes various kinds and types of gages and precision measuring instruments.—The Sheffield Corp., Dayton 1, Ohio.

U-651 **Automatic Gaging and Sorting.** 20-page bulletin 7252 illustrates and describes various types of electromechanical and electronic devices for rapid gaging and sorting of all types materials and machined products. Includes many typical applications.—Federal Products Corp., 1144 Eddy St., Providence 1, R. I.

U-652 **Precision Gages.** 8-page Spring issue of "Daco Doings" features articles on production of precision carburetors, design of automatic machinist, and special gages for inspection of turbine blades.—Daco Machine & Tool Co., 202 Tillary St., Brooklyn 1, N. Y.

U-653 **Angle Computer.** 4-page illustrated Bulletins 4, 5, and 2A cover features, operation, and typical applications of the "Studler" angle computer

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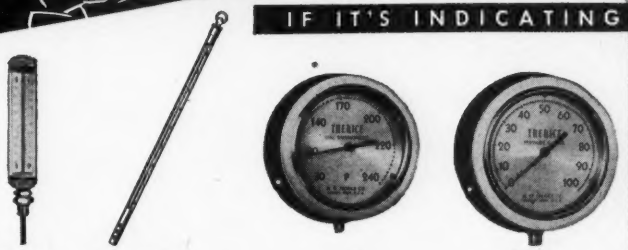

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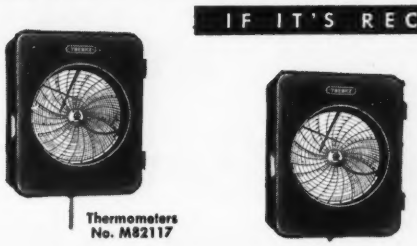

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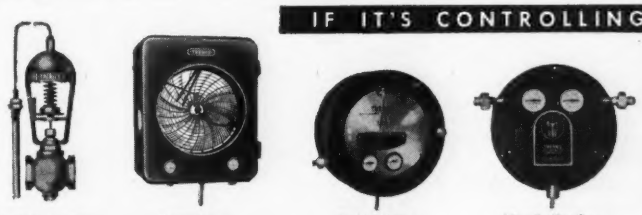

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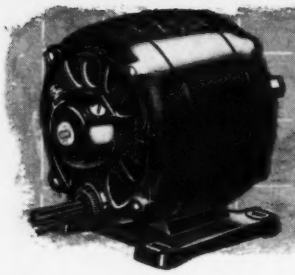

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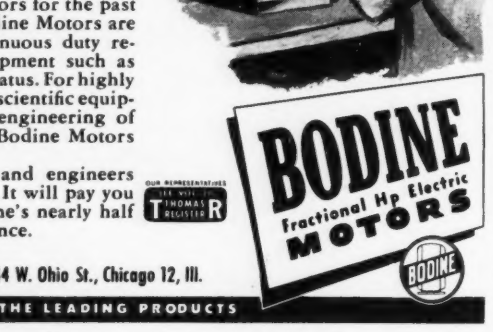

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NEW LITERATURE

and universal compound angle plate for layout and inspection of tools, dies, etc., through 360 degrees in 3 degrees of freedom.—The Angle Computer Co., 1709 Standard Ave., Glendale 1, Calif.

U-654 **Surface Hardness.** 4-page brochure covers maker's "Metalometer" with "Peabody" anvil for measuring surface hardness.—Peabody Industries, Inc., 12129 Hamilton Ave., Highland Park, Mich.

U-655 **Thickness Gage.** 4-page brochure illustrates and describes needle-type thickness gage with new stand and hardness-measuring attachment.—Gardner Laboratory, Inc., Bethesda 14, Md.

Valves

U-656 **Diaphragm-motor Valves.** 8-page Specification Sheet 420 describes and illustrates "Honeywell Series 700" single-seated diaphragm valve for wide-band proportional control. Includes data on actuators, body, trim, pressure drops, ratings, and mounting.—Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Sta. 40, Wayne & Windrim Aves., Phila. 44, Penna.

U-657 **Integral-seat Valves.** 8-page illustrated Catalog 12-G1 describes "Univalve" integral-seat all-purpose forged-steel valves rated for 1,500 and 2,500 lbs. Includes specifications, chemical analyses, and physical characteristics. Special section illustrates step-by-step simple disassembly procedures.—Dept. C. U., Edward Valves, Inc., 1200 West 145th St., East Chicago, Ind.

U-658 **Liquid-level Control Valves.** 12-page Bulletin 530 illustrates and presents features and specifications for maker's aircraft fuel-tank liquid-level control valves.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

U-659 **Fuel-selector Valves.** 16-page illustrated Bulletin 521 describes features and specifications for maker's line of aircraft fuel-selector valves.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

U-660 **Valves.** 24-page catalog illustrates and describes line of precision valves, including pressure relief, check, on-off, angle needle, instrument vacuum control, and plug valves. Includes sizes and engineering data.—Kohler Co., Kohler, Wis.

U-661 **Oil Valve.** 2-page Catalog 719 illustrates and describes maker's "Series D and E" oil valves for micrometering service. Includes features, specifications, and capacities.—Hauck Mfg. Co., 124 10th St., Brooklyn 15.

U-662 **Adjustable Valves.** 8-page Catalog 713 illustrates and describes maker's 10-position adjustable flow valves for gas and air. Includes principles, capacities, and specifications.—Hauck Mfg. Co., 124 10th St., Brooklyn 15, N. Y.

U-663 **Safety Relief Valve.** 4-page Bulletin 290 describes a new safety relief valve, "Type F 51," and "Type E" reducing and regulating valve. Includes features and capacities—A. W. Cash Valve Mfg. Corp., 666 E. Wabash Ave., Decatur, Ill.

Pumps

U-664 **Controlled-volume Pumps.** 24-page illustrated Bulletin 351 covers maker's line of air-operated pumps and systems, details of construction, operation and application. Includes tables for pumps handling 1.4 to 405 gph. against discharge pressures to 21,000 psi.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Penna.

U-665 **Air Pumps.** 6-page folder Bulletin 300 illustrates and describes maker's air pressure or vacuum pumps designed for laboratory application. Includes specifications.—Eberbach Corp., Ann Arbor, Mich.

U-666 **Hydraulic Equipment.** 20-page illustrated catalog covers maker's large line of oil hydraulic pumps, cylinders, valves, motors, presses, etc. Includes specifications.—Superdraulic Corp., 14256 Wyoming Ave., Detroit 4, Mich.

Tubing and Fittings

U-667 **Tubing.** 28-page Catalog F-1456A lists, with drawings and specifications, maker's complete line of industrial tube and pipe fittings, drain cocks, etc. Contains table of burst pressures.—The Weatherhead Co., 300 E. 131 St., Cleveland 8, Ohio.

U-668 **Tubing Fittings.** Bulletin 4310 B 3 illustrates and describes new "Triple-Lok" tubing fittings with "Dry-seal" pipe threads. Includes comparison with old "Triple" fittings.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Power Supplies

U-669 **Power Supplies.** 2-page Bulletin 109 covers maker's regulated rectifiers for computer applications.—Power Equipment Co., 55 Antoinette St., Detroit 2, Mich.

U-670 **Power Supplies.** Illustrated bulletin describes maker's line of new "A.E.C." regulated power supplies with ½ and 1/10 percent regulation.—American Electroneering Corp., 5025 W. Jefferson Blvd., Los Angeles 16, Calif.

Telemetering and Communication

U-671 **Carrier Signals.** 12-page Vol. 1 No. 4 issue "The Lenkurt Demodulator" features article "Transmission of Signals over Carrier System Channels." Includes circuit, block diagrams, and filter characteristics.—Lenkurt Electric Co., San Carlos, Calif.

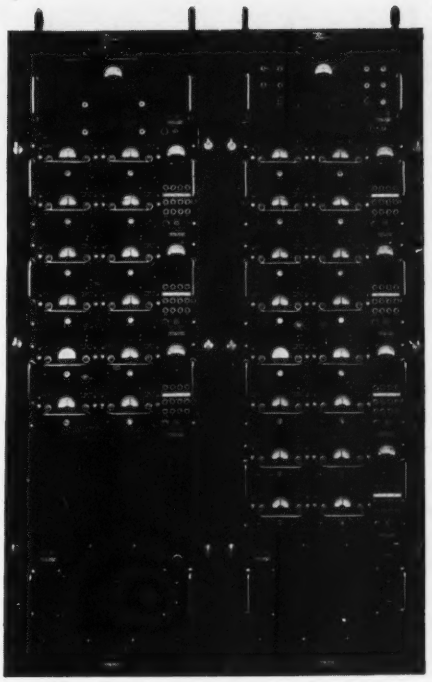
U-672 **Telemetering Components.** 86-page Product Specifications Catalog covers design features, applications, and specifications for maker's accelerometers, aeroheads, gyros, pressure transmitters, precision "pots." Appendices define terms and present pertinent tables and other data.—G. M. Giannini & Co., Inc., 332 Springfield Ave., Summit, N. J.

Electrical and Electronic Test Instruments

U-673 **VTVM.** Bulletin illustrates and describes new "Model 314" electronic voltmeter for a-c. voltage measurement from 0.001 volt to 1000 volts over frequency range from 15 cycles to

27

TELEMETERING CHANNELS AUTOMATICALLY SEPARATED WITH THE Bendix-Pacific ELECTRONIC DECOMMUTATOR



Automatic separation for up to 27 information channels on one commutated subcarrier is now possible with this Bendix Model THC-1 Electronic Decommutator. The equipment can be used with any standard FM/FM telemetering receiving station.

Accuracy is such that the nominal error of the equipment is less than 1.0% and this will not be adversely affected by ambient temperatures between 20° and 110°F and relative humidity up to 80%.

The decommutator is capable of separating 27 information channels at 2.5, 5, or 10 revolutions per second and 15 information channels at commutation speeds of 5, 10 or 25 revolutions per second.

Major electronic assemblies of the equipment are the decommutator control, four channel separators, information gates, and the dual power supply. Nominal output is ±5.0 milliamperes into a 330 ohm load for band edge to band edge deflection.

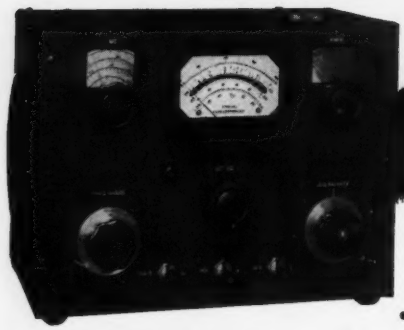
Complete information on the equipment can be obtained by writing the manufacturer.

Bendix

Pacific Division

Bendix Aviation Corporation

NORTH HOLLYWOOD, CALIF.



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17 YEARS OF RESEARCH PRODUCED THESE IMPORTANT FEATURES

- Single, easy-to-read meter, with parallax correction, for all functions.
- Q indicating voltmeter: 50 to 400.
- Multiply Q scale: 0.5 to 3.0.
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- Additional accurate expanded scale for measuring low values of Q.
- A counter type resonating capacitor dial for improving setting and reading accuracy.
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- Low internal inductance, capacitance and resistance.
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- Tunable oscillator in four ranges calibrated to high accuracy.
- Compact, simple, rugged construction.

This new 190-A Q Meter measures an essential figure of merit of fundamental components to better overall accuracy than has been previously possible. The VTVM, which measures the Q voltage at resonance, has a higher impedance. Loading of the test component by the Q Meter and the minimum capacitance and inductance have been kept very low.

SPECIFICATIONS—TYPE 190-A

FREQUENCY RANGE: 20 mc. to 260 mc.

RANGE OF Q MEASUREMENT:

Q indicating voltmeter	50 to 400
Low Q scale	10 to 100
Multiply Q scale	0.5 to 3.0
Differential Q scale	0 to 100
Total Q indicating range	5 to 1200

PERFORMANCE CHARACTERISTICS OF INTERNAL RESONATING CAPACITANCE: Range — 7 mmfd. to 100 mmfd. (direct reading).

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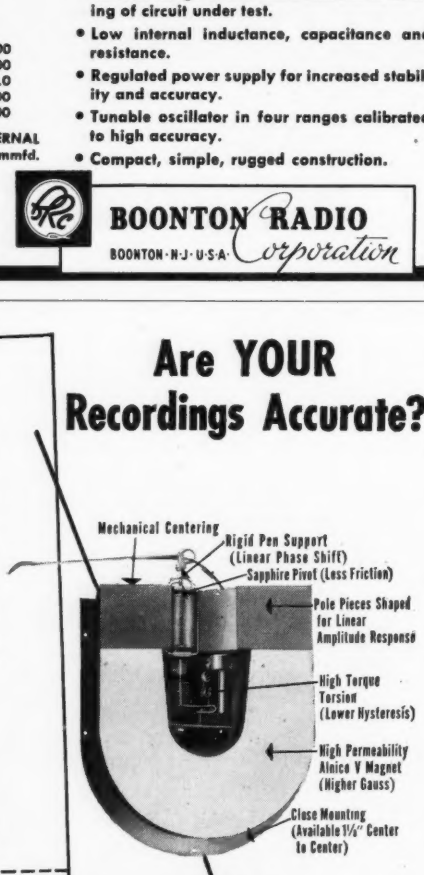
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NEW LITERATURE

6 Mc. Includes features and specifications.—Ballantine Laboratories, Inc., Boonton, N. J.

U-674 **Test Bridge.** 2-page Bulletin 620 illustrates and describes new low-priced "Type Z" measuring bridge for d-c. and a-c. measurements. Includes features.—Herman H. Sticht & Co., 27 Park Place, New York, N. Y.

U-675 **Oscillograph.** 8-page illustrated bulletin presents features, applications, operation and pricing data for "Type PM-18" oscillograph for simultaneous recording of 2, 3, or 4 steady-state or varying quantities.—General Electric Co., Schenectady 5, N. Y.

U-676 **Magnetic Measurements.** 12-page Brochure GEC-777 illustrates and describes maker's equipment for measuring magnetic properties, including gauss meter, indicating fluxmeter, recording fluxmeter, and fluxmeter calibrating unit.—General Electric, Schenectady, N. Y.

U-677 **Instrument Amplifier.** 4-page illustrated brochure describes features and applications of maker's "Phantom Repeater Model 102" with high input-impedance, low output-impedance and gains of 1.0, 10, and 100 for use with test instruments.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

U-678 **Vacuum-tube Electrometers.** 8-page brochure illustrates and describes maker's vacuum-tube electrometers and accessories. Includes specifications and typical applications. 2-page reprint of *Instruments* article covers features and applications.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

U-679 **VT Wattmeter.** 2-page illustrated brochure describes features, principles, operation, and typical applications of maker's new vacuum-tube wattmeter with 500,000-ohm impedance and response from 20 to 3000 cps.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

U-680 **Wheatstone Bridges.** 4-page issue No. 2 of "Rubicon Notes" contains 3-page article on wheatstone-bridge principles and description of maker's bridges.—Rubicon Co., Ridge Ave at 35th St., Phila. 32, Penna.

U-681 **Circuit Tester.** 2-page bulletin illustrates and describes indicator for testing motors, solenoids, and other electro-magnetic circuits. Gives advantages and specifications.—H-B Indicator Co., 915-B Terminal Sales Bldg., Seattle 1, Wash.

U-682 **Tuning-Fork Resonator.** 4-page Folder 101 illustrates and describes maker's "Model DSLA-400-K-N4085" 400-cycle tuning-fork resonator. Covers features, operation, specifications.—Philamon Laboratories, 5717 Third Ave., Brooklyn 20, N. Y.

U-683 **Signal Generators and Frequency Counters.** 4-page Form 3547 illustrates and describes (1) new "Decalator" crystal-controlled decade-switched oscillators that provide 9,000 separate frequencies, (2) "Decaviders"

that divide high-frequency signals for use with lower-frequency counters, and (3) "Deca-Sweep" combined sweep oscillator and precision signal generator. —Decade Instrument Co., Box 153, Caldwell, N. J.

U-684 **Phase Meter.** Illustrated brochure contains features and specifications of "Model A-1" direct-reading phase meter for indicating phase difference of two signals from 20 to 50,000 cps.—Cubic Corp., 2841 Canon St., San Diego 6, Calif.

U-685 **ILS Test Equipment.** Illustrated bulletin describes function, specifications, and prices of "Model TS/67-C-1" signal generator for testing instrument landing systems.—American Electroneering Corp., 5025 W. Jefferson Blvd., Los Angeles 16, Calif.

U-686 **Microwave Equipment.** Illustrated brochures describe (1) portable microwave calorimetric wattmeter, (2) microwave pulse-measuring wattmeter, and (3) maker's line of standard microwave components—junctions, couplers, cavities, crystal holders, slotted lines, etc.—Cubic Corp., 2841 Canon St., San Diego 6, Calif.

Recording Systems

U-687 **Amplifiers and Recorders.** 26-page illustrated catalog contains eleven bulletins describing maker's industrial recording systems, including galvanometer, recorders, amplifiers, and integrated systems.—Sanborn Co., Industrial Div., Cambridge 39, Mass.

U-688 **Magnetic-tape Recording.** 4-page illustrated Brochure PD-16 covers development features, and specifications of a 50-channel recording and playback unit, with data interpretation system.—Cook Research Laboratories, 8100 Monticello Ave., Skokie, Ill.

Panel Instruments

U-689 **Switchboard Instruments.** 20-page Bulletin GEC-218B covers maker's large line of voltmeters, ammeters, wattmeters, varmeters, frequency meters, power-factor meters, synchroscopes, and temperature meters.—General Electric, Schenectady, N. Y.

U-690 **Panel Meters.** 2-page brochure covers maker's ammeters, voltmeters, recording instruments, and tachometer.—Maritime Switchboard, 336 Canal St., New York 13, N. Y.

Electrical & Electronic Components

U-691 **Electronic Components and Instruments.** 48-page Supplement 130 illustrates and describes hundreds of electronic components and test instruments handled by large distributor.—Allied Radio, 833 W. Jackson Blvd., Chicago 7, Ill.

U-692 **Electronic Components.** 8-page bulletin describes electronic components and instruments, such as tubes, loudspeakers, transformers, etc., handled by large distributor.—Hudson Radio & Television Corp., 48 W. 48th St., New York 19, N. Y.

U-693 **Resistors and Switches.** 2-page April issue of "The Ohmite News" features articles on "JAN-R-26A" resistors, "Ohmite Thin" resistors, open-

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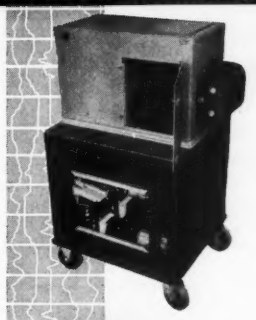
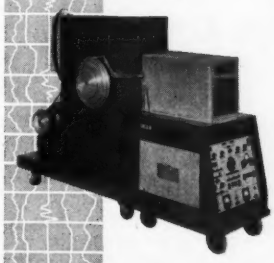
with 6 elements is *flat from 0 to 200,000 cycles per second*, and its traces have a writing speed of *5 million inches per second.*



Fast transients and high-frequency phenomena now can be accurately recorded.

Several types of continuous-drive record magazines are available for 6-inch sensitized paper and film, and for 35-mm film. The magazine shown on the oscillograph at the left accommodates 100-foot rolls of record paper.



Drum-type magazines, both small and large, are valuable for short high-speed records. The large drum-type magazine at the left has a drum 3 feet in diameter and 6-inches wide. It can be driven at 3000 RPM for a *chart speed of 6000 inches per second* when high resolution is needed. It can be used to take one 10-foot record or a larger number of shorter records.

The ASC-10 6-element direct-coupled amplifier will drive the SC-16 oscillograph from potentials of millivolt level.

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QUICK-CHANGE TRANSMISSION for wide range of record speeds.

PRECISION TIME LINES.

Z-AXIS MODULATION for timing to one-tenth millisecond.

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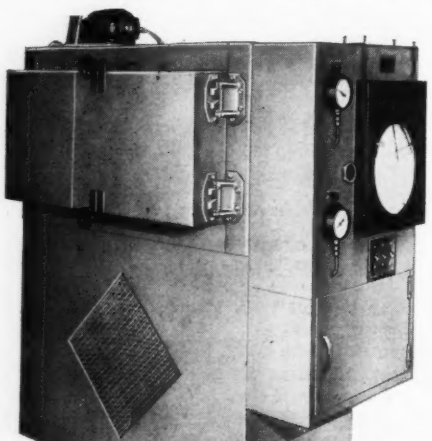

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NEW LITERATURE

type tap switches, and "Dividohm" tapped resistors.—Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

U-694 **Precision Resistors.** 6-page illustrated brochure "Section R" contains full, descriptive material on precision wire-wound resistors, hermetically sealed resistors, and miniature resistors. Includes charts, diagrams, and tables.—The Daven Co., Dept. RR, 191 Central Ave., Newark 4, N. J.

U-695 **Deposited-carbon Resistor.** 2-page Data Bulletin B-7 covers applications and specifications of maker's deposited-carbon 0.5-watt resistors.—International Resistance Co., 401 N. Broad St., Philadelphia 8, Penna.

U-696 **Deposited-carbon Resistors.** 4-page Bulletin 1 illustrates and describes high-stability deposited-carbon resistors. Includes features and operational data—Radell Corp., 7900 Pendleton Pike, Indianapolis 26, Ind.

U-697 **Boron-carbon Resistor.** 2-page Data Bulletin B-6 covers applications and specifications of maker's 0.5-watt boron-carbon resistors, a new development in stable film-type resistors.—International Resistance Co., 401 N. Broad St., Philadelphia 8, Penna.

U-698 **Resistors and Rheostats.** 14-page illustrated bulletin describes features, construction, and specifications for maker's line of resistors and rheostats.—Tru-Ohm Products, 2800 N. Milwaukee Ave., Chicago 18, Ill.

U-699 **Linear-motion Potentiometers.** 18-page illustrated brochure contains general features and detailed specifications of maker's linear-motion potentiometers with one, two, and three resistance elements and pickoff actuated by linear motion or pendulum on ball bearings.—Edcliff Instruments, 850 S. Fair Oaks Ave., Pasadena 2, Calif.

U-700 **Phasing Potentiometer.** 2-page illustrated Industrial Bulletin 100 covers new "Series C-200 External Phasing Potentiometer" for computers and other instruments. Includes complete specifications.—DeJur-Amsco Corp., Ind. Sales Div., 45-01 Northern Blvd., L. I. 1, N. Y.

U-701 **Capacitors.** 16-page Vol. 17 No. 5 issue of "The CD Capacitor" features article on voltage regulation of high-voltage supplies, "Radio Trading Post," and description of maker's electrolytic and "Tiny-Mike" capacitors.—Cornell-Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

U-702 **Capacitors.** 12-page Catalog MP-2 covers principles, features, and characteristics of "Pyramid" metallized-paper capacitors with self-healing characteristics. 8-page catalog covers "Pyramid" hermetically sealed, miniature paper capacitors with metal-glass end seals.—Hudson Radio & Television Corp., 48 W 48 St., New York 36, N. Y.

U-703 **Transformers.** 2-page Form 393 describes maker's power and filament transformers particularly suitable for TV replacement.—Standard Transformer Corp., 3580 Elston Ave., Chicago 18, Ill.

U-704 **Pulse Transformers.** 2-page brochure covers features and characteristics of maker's three-winding pulse transformer for low-power applications.—Engineering Research Associates, Inc., 1902 West Minnehaha Ave., St. Paul 4, Minn.

U-705 **Clipper Diode.** 2-page data sheet gives dimensions and electrical characteristics of new "Los Gatos Type 719A" clipper diode with pulse-current characteristics to 20 amperes and plate-current characteristics to 800 ma.—Lewis & Kaufman, Inc., 110 El Rancho Ave., Los Gatos, Calif.

U-706 **Twin Power Triode.** 2-page Data Sheet 6082-12-51 gives specifications and characteristics of "Type 6082" low-mu, high-perveance, twin power triode.—Tube Dept., Radio Corp. of America, Harrison, N. J.

U-707 **Frequency-sensitive Relays.** 8-page illustrated Bulletin 33 describes new frequency-sensitive relays that use resonant reeds to operate a relay. Includes principles and applications in multichannel transmission of signals.—James G. Biddle Co., 1316 Arch St., Phila. 7, Penna.

U-708 **Time-delay Relay.** 2-page issue No. 19, Vol. 1 of "Cook Diaphlex Newsletter" covers features and specifications of maker's time-delay relay adjustable from 0.1 to 1.0 second.—Cook Electric Co., 2700 North Southport Ave., Chicago 14, Ill.

U-709 **Switches.** 32-page catalog illustrates and describes maker's large line of key switches, switchboard lamps, caps, impulsing devices, jacks and plugs, etc.—International Automatic Electric Corp., 1033 W. Van Buren St., Chicago 7, Ill.

U-710 **Electrical Fittings.** 12-page Catalog 52 illustrates and describes maker's complete line of solderless wire connectors, cable and conduit fittings, and wiring devices.—Buchanan Electrical Products Corp., Hillside, N. J.

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U-711 **Multi-contact Connectors.** 4-page Vol. 5 No. 3 issue of "Amphenol Engineering News" features articles on use of maker's connectors in "Sheffield Measuray Gages," "Bowser Test Chambers," and "Minneapolis-Honeywell Protectorelays."—American Phenolic Corp., 1830 S. 54 Ave., Chicago 50, Ill.

U-712 **Sealed Connectors.** 4-page Bulletin RS-3 illustrates and describes Type RS06" sealed connectors for relays. 2-page Bulletin GS-3 covers

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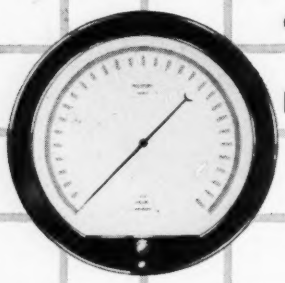

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NEW LITERATURE

"Type GSO2" hermetically sealed receptacle.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

U-713 **Subminiature Connectors.** 8-page small folder illustrates and describes new "D series" subminiature multi-contact connectors. Includes performance test data.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

U-714 **Multi-contact Connectors.** 32-page Bulletin PO4-1952 illustrates and describes maker's large line of audio connector series of plugs, receptacles, and accessories. Includes specifications. —Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

U-715 **Computing Components.** 4-page No. 1 issue of "The Lightning Empiricist" features articles on use of the analog computer in governor design, on computing components, and others on computers and accessories.—Geo. A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.

U-716 **Foot-operated Switches.** 12-page catalog illustrates and describes maker's line of "Linemaster" foot treadle switches.—Linemaster Switch Corp., Woodstock, Putnam, Conn.

Miscellaneous

U-717 **Mercury Trap.** 2-page illustrated bulletin gives complete data dimensions, pore size and permeability of "Mercureceiver" device designed to prevent loss of mercury from mercury-containing instruments.—Chemiquip Co., 6 E. 97th St., New York, N. Y.

U-718 **Air Filter.** 2-page illustrated Bulletin CU-4 describes new "Utra-Aire" space filter for air purification of toxic and radioactive particles to 0.3 micron. Includes features and applications.—Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Penna.

U-19 **Multiplex Alternators.** 4-page Bulletin 7110 illustrates and describes maker's multiplex alternators for controlling pumps, blowers, compressors, and burners in any sequence.—Automatic Control Co., St. Paul 4, Minn.

U-720 **Pantograph.** 12-page bulletin describes "Lasico Model 151" suspended precision pantograph with 36 x 48-inch rectangle capacity at 1:20 ratio.—Los Angeles Scientific Instrument Co., 108 W. 6th St., Los Angeles 14, Calif.

U-721 **Remote Positioning.** 4-page brochure illustrates and describes maker's hydraulic positioning device.—Superdraulic Corp., 14256 Wyoming Ave., Detroit 4, Mich.

U-722 **Manhole Fittings.** 2-page Bulletin Form 603 illustrates and describes maker's manhole fittings.—Lukens Steel Co., Coatesville, Penna.

U-723 **Meter Houses.** 20-page illustrated Catalog 6 covers maker's large line of weatherproof meter houses. Includes types, features, protectors, air jackets, and typical applications.—Moran Furnace & Sheet Metal Co., 807 E. 5th Pl., Tulsa, Okla.

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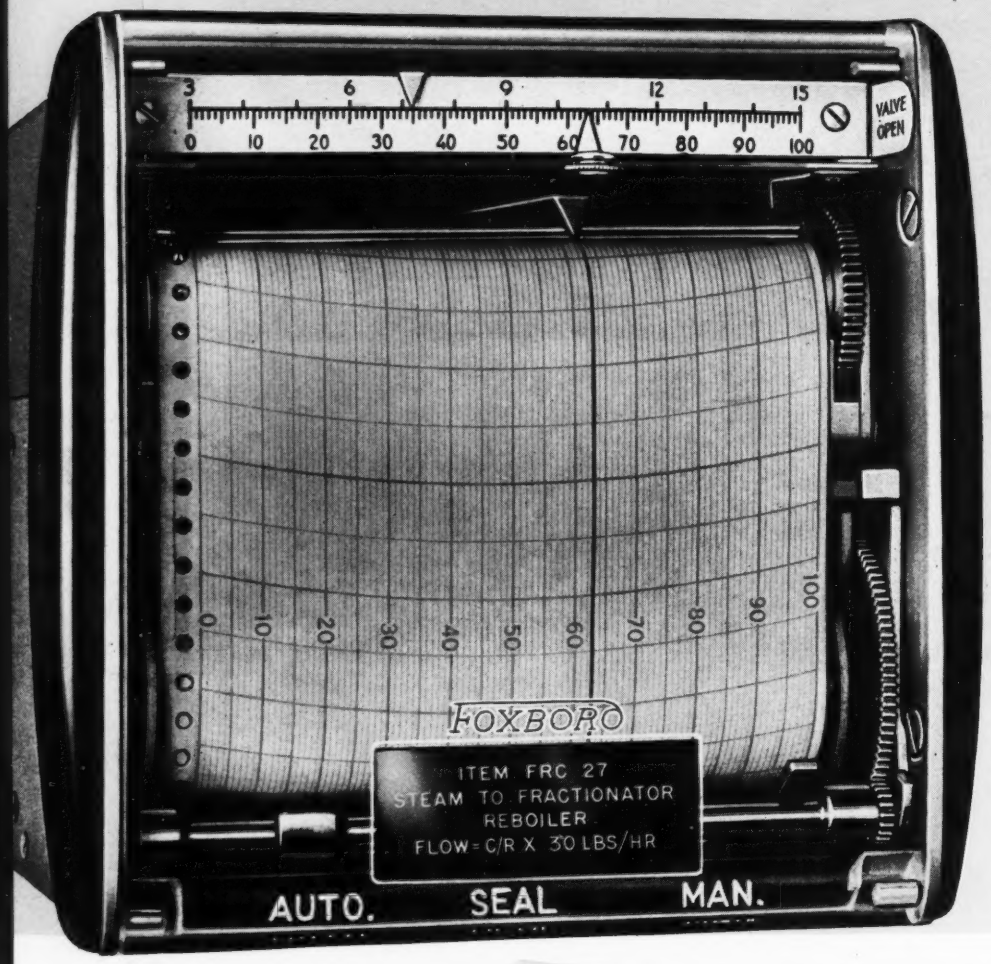

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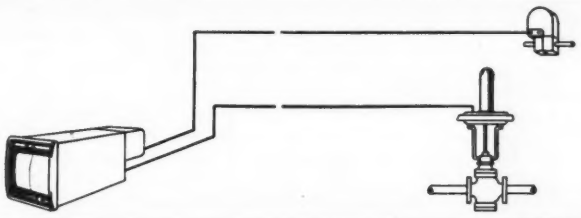
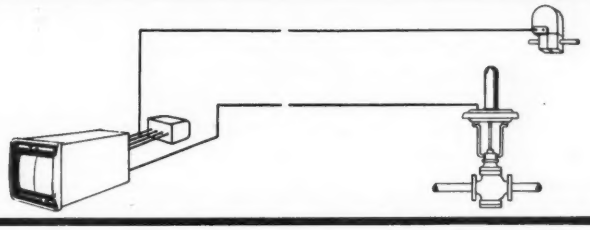
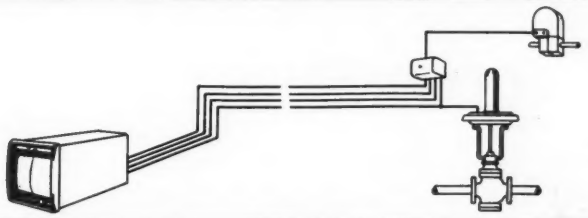
1 **Consotrol Recorder with M/58 Consotrol Controller... integrally-mounted**



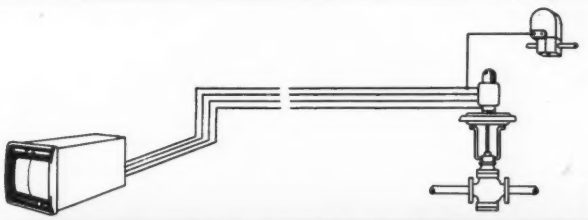
2 **Consotrol Recorder with M/58 Consotrol Controller... rack-mounted**



3 **Consotrol Recorder with M/58 Consotrol Controller... field-mounted**



4 **Consotrol Recorder with valve-mounted M/59 Consotrol Controller.**



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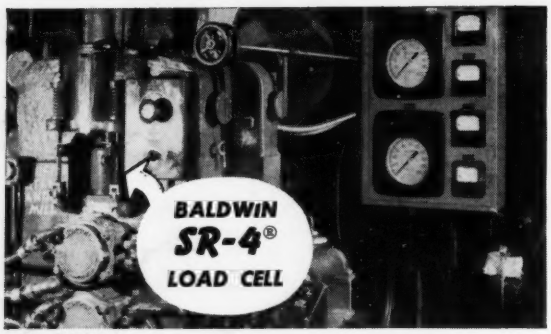

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ISA Exhibit Guide
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117 New Instruments
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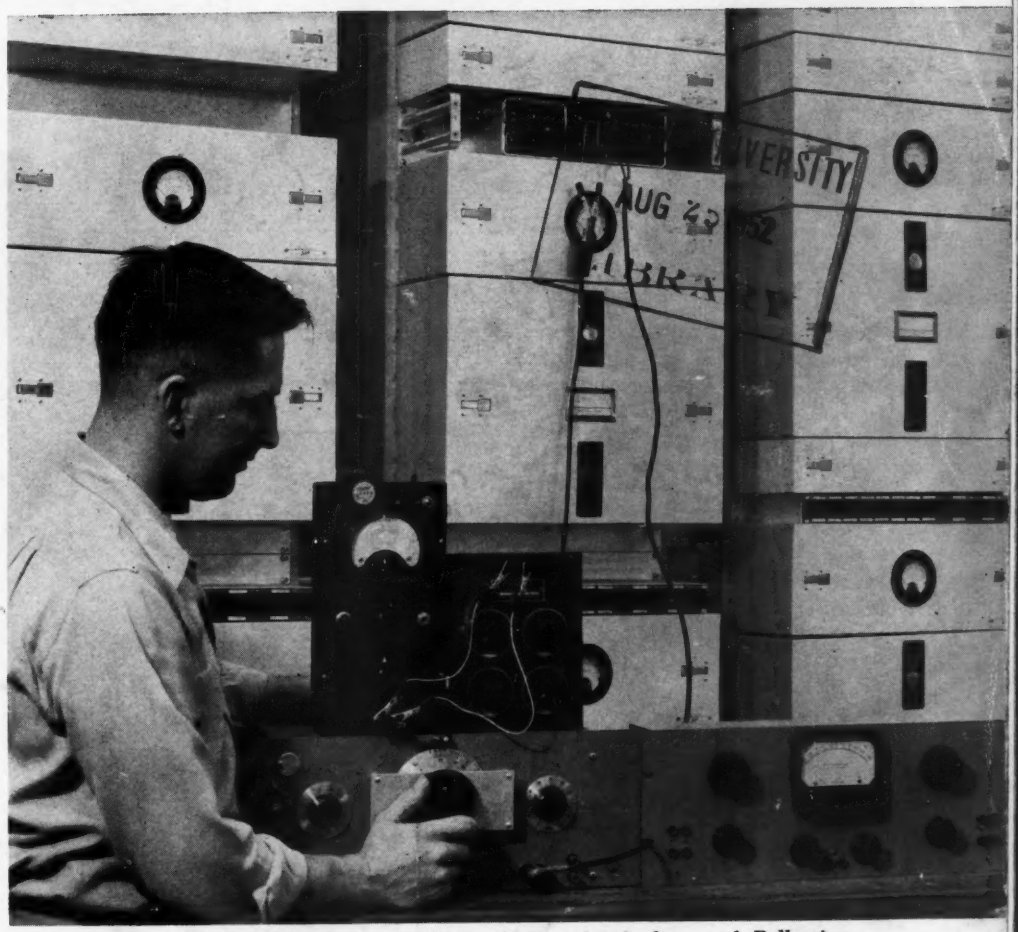
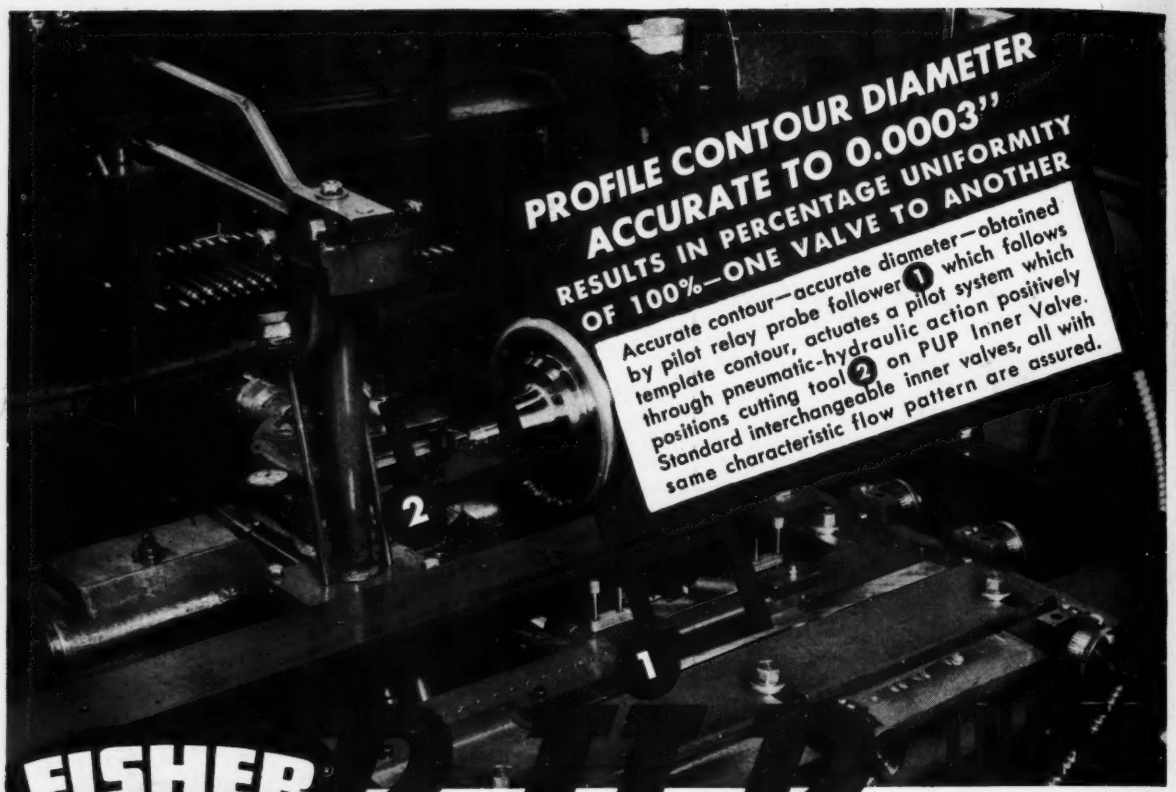
AUGUST • 1952



Hewlett-Packard test oscillator, Ohmite decade box, and Ballantine vacuum-tube voltmeter or transmission-measuring set are used to check Lenkurt filters. Story on page 954. *(Courtesy Lenkurt Electric Co.)*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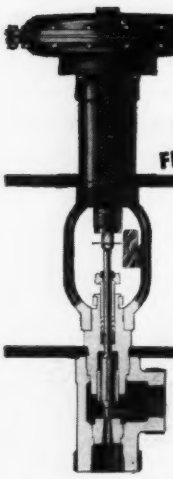

Type 57T-DA direct acting diaphragm motor valve showing Micro-Form Pup in Fisher high pressure cast steel Design "D" angle body.

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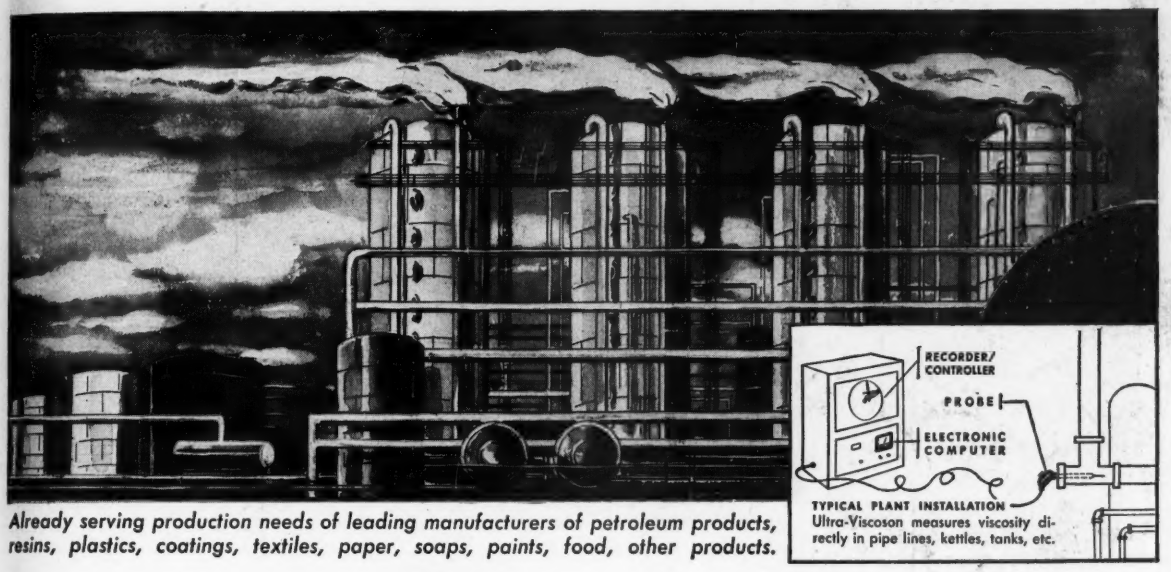

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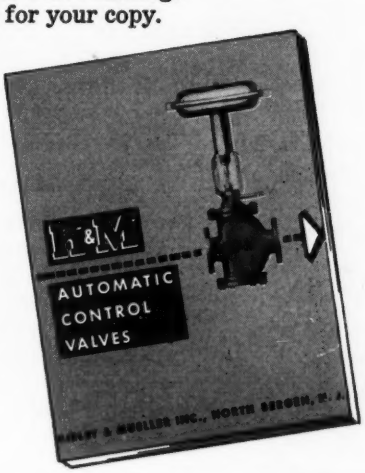

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